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SWINGING A GREAT POLAR BEAR OVER THE SHIP'S SIDE ON TO THE DECK

THE CAPTURE OF "SILVER KING"—[SEE PAGE 169]

Stellar Magnitudes*

The Problem of Measuring the Brightness of a Star

By J. E. Maybee

It is an oddity of terminology and a survival of immemorial custom that a term expressive of size is used to designate the brilliancy of a star. Metaphorical language seems almost out of place in an exact science like astronomy; yet to the ordinary dabbler in astronomy the term "magnitude," used to express light giving power, does not appear unapt, for we are well accustomed to speak of a man of brilliant intellectual or moral acquirements as a "big" man; and, to the non-scientific, undoubtedly the biggest and most important point about a star is its relative brilliancy of appearance. So we shall accept the term "magnitude" as expressing the luminosity of a star as viewed from our earth.

The term is, as already suggested, an old one and comes to us from Ptolemy (140 A. D.). In the Ptolemaic cosmogomy, as is well known, the stars were supposed to be set in a crystalline sphere and were all at the same distance from the earth. It was not an unnatural assumption then that differences in brightness indicated difference in size. The final triumph of the Copernican theory of the universe resulted in the passing away forever of *this* theory of stellar magnitudes, but another quite as erroneous took its place, namely, the assumption that all stars are of the same intrinsic brilliancy and that the difference in their appearance is due simply to differences in their distances from us. We now know that some of the most brilliant of the stars are comparatively distant and that others relatively dim are among our nearest neighbors. We also know that there are dark stars. Algol's dark companion, for example, and it is reasonable to assume, therefore, that stars vary not only in their distances from us, but in their intrinsic luster as well.

Stellar photometry is the branch of astronomical science which undertakes the task of determining the relative apparent brightness of the stars and any variations therein.

It is an important branch of astronomical work, for when combined with determinations of parallax and spectroscopic analysis it enables us to get an approximate idea of the real sizes of stars. For it is evident that, given a star which differs from another in brightness, its distance and the *quality* of the light being the same, the difference of brightness gives at once a measure of the relative sizes of the two. Or, if the brightness and quality of light are the same, but the distances different, the two stars vary in size directly as the square of the distance.

Working along such lines, it is found, for example, that though 61 Cygni, magnitude 5.4, distance 6.5 light years, is only one-seventh the solar mass, Arcturus, magnitude 0.24, distance 127 to 160 light years, is possibly equal to a million suns.

Having arrived at an idea of the meaning of "magnitude" as applied to stars, and of the importance of stellar photometry, we shall now consider on what lines stellar magnitudes are determined. Our present system of expressing magnitudes possesses several incongruities. In the first place, the smaller the magnitude the brighter the star. There would be no great trouble about this, however, were it not for the fact that some stars are brighter than first magnitude. Hence we have the anomaly of stars of 0 magnitude and even "—" magnitudes. Some further confusion is due to the fact that the eye does not perceive the actual ratio of brightness between two stars. For instance, a star of the 3.5 magnitude might be supposed to be a mean between a star of the sixth magnitude and a star of the first magnitude. But not so, a star of 3.5 magnitude is 12.6 times as bright as a star of the sixth magnitude. And a star of the first magnitude is 100 times as bright as a star of the sixth magnitude, and therefore 8 times brighter than a 3.5 magnitude star.

Following this out, it appears that if the brightness of a sixth magnitude star be called 1, that the brightness of a fifth magnitude star is 2.512, of a fourth magnitude star 6.3, of a third 15.8, say 16, of a second magnitude star almost 40 and of the first just 100. Magnitude 0.0 is represented by 251.2 and magnitude —1 by 631. In each case the brightness relative to the sixth magnitude star is found by raising 2.512 to a power represented by the difference in the magnitudes. It follows then that to determine how many times one star is brighter than another you subtract the lesser magnitude from the greater and raise 2,512 (the light ratio) to a power represented by this difference. This is easy when dealing with whole magnitudes, but rather more difficult when stars differ by fractions of a magnitude. But logarithms help us out of the difficulty. The logarithm of 2.512 is 0.4, and we may raise 2,512 to any desired power by multiplying 0.4 by the index of the desired power, which gives us the logarithm of the desired power, and a reference to a table of logarithms will give the number corresponding to the logarithm so found, which represents the number of times the lower magnitude star is brighter than the higher magnitude star. Let us take a case. Regulus is of a magnitude represented by 1.34, Sirius is of a magnitude represented by —1.58 (Miss Clerke). Subtract —1.58 from 1.34 and we get 2.92. Multiply 2.92 × 0.4, the logarithm of 2.512, the light ratio, and we have 1.168, and this is the logarithm of 14.72, so that Sirius is 14.72 times as bright as Regulus. It should be clear then that the actual difference in brightness between two stars is much greater than it appears to the naked eye, for the eye is not impressed in proportion to the actual difference, but only in proportion to the logarithm of that difference, or, to put it differently, stars which to the eye appear to form an arithmetical progression in brightness, in reality form a geometrical progression. This will explain why a photographic tyro is so often deceived in the photographic value of the evening light. His eye may tell him that the light is approximately midway between two known standards, and therefore he may decide on an exposure, say, of double that he would give under the brighter standard, while in reality the actinic value may be so much lower that eight times the exposure is necessary to proportionately affect the plate.

The problem of stellar photometry is not an easy one, as there are so many difficulties in the way of getting uniform conditions for observing. For instance, in the country stars look much brighter than they do in the city, and on a mountain brighter than they do in the level country. W. H. Pickering also thinks the seeing is much better nearer the equator than in the temperate zones. Stars near the zenith also appear brighter than when near the horizon, and as some stars to an observer in a given station never rise far above the horizon his observations will give a lower value to the brightness of such stars than if they were observed near the zenith. Thus observations of star magnitudes must have a correction applied reducing them to standard distance above the horizon, if they are not observed under similar conditions. Further, eyes differ in their sensitiveness to light, and thus one observer may get results different from those of another.

The color of a star also may affect the results, as some eyes are more senstive to one color than another. Another curious thing is that if we take a green light and a red light of equal intensity, and either double or halve the intensity, they will no longer appear equal to the eye. When the intensity of both is doubled the red will appear the brighter, and when halved the green will appear the brighter. It is also to be remembered that the atmospheric absorption for the different parts of the spectrum is not the same. When all these things are considered it is no wonder that the photometric determinations of different observers vary.

It will be interesting, I think, to consider the number of the stars of different magnitudes. Here again doctors differ, but I have used the figures given by Todd (1897): I. = 20, II. = 65, III. = 220, IV. = 500, V. = 1,400, VI. = 5,000, total 7,205. The number increases up to the tenth magnitude by a sort of rough geometrical progression, the stars of a given magnitude being from 3 to 3.75 times more numerous than those of the next higher (i e., brighter), so that there are about 720,000 stars of the tenth magnitude. After that the ratio decreases so that it is probable that in the first 16 or 17 magnitudes there are not more than about 100,000,000 stars.

A study of the total light-giving power of stars of the different magnitudes reveals some unexpected results. It will be remembered that the brightness of stars of different magnitudes increases in a geometric progression, 2,512 being the ratio; but the number of the stars of the different magnitudes, from the first downward to 10, increases as above stated in a geometric progression in which the ratio is from 3 to 3.75, consequently as the magnitude decreases the total light increases. One curious result of this is that we get over twenty times as much light from stars we cannot see with the naked eye than from those we can see.

The estimates of the total light received from the stars vary widely. Newcomb's experiments would put it in the neighborhood of about $^1/_{80}$ of the light of the full moon. Prof. Young put it as high as $^1/_{60}$. Newcomb's estimates up to the tenth magnitude are interesting, and I shall quote them. Taking the light of all those of the first magnitude as unity, 1st magnitude = 1; 2nd = 1.4; 3rd = 2; 4th = 2.8; 5th = 4; 6th = 5.7; 7th = 8; 8th = 11.3; 9th = 16; 10th = 22.6.

Stars from magnitudes 1 to 6 are naked eye stars, and their proportion of the total light is 16.9 units, only about $^1/_5$ of the total light up to the 10th magnitude.

As we estimated that the naked eye stars give about $^1/_{20}$ of the total light received from all the stars and the stars down to the 10th magnitude give five times as much, it is evident that all the stars must give four times the light of those down to the 10th magnitude, and consequently the stars below the 10th magnitude give three times as much light as those from 1st to 10th.

It is very clear, then, that we would not suffer a very serious diminution of sky light at night if all the stars that delight our unaided eyes were blotted out, while the extinction of the telescopic and photographic stars would be a very serious deprivation. Another instance, by the way, of the importance of unseen things. Who can say but that higher senses or a better development of our present senses might not reveal other and more important unseen influences than the light of the stars.

I might say in parody of Hamlet "There are more things in heaven and earth, Horatio, than are seen by your astronomers."

I need say little about the ordinary methods of observing star magnitudes.

One is by naked eye comparison, but more important scientifically are the extinction method by means of a wedge of neutral-tinted glass, and the equalization method in which the polariscope is employed.

The photographic method is less employed, and being also less well known deserves fuller mention.

Photography has been probably the most important of the sister arts or sciences which have been pressed into the service of astronomy. It has enabled the astronomer to penetrate into the depths of space far beyond the ken of our largest visual telescopes; it has made possible the charting of the heavens in a manner impossible by the laborious method of visually observing and charting individual stars, and now it comes to our aid in stellar photometry.

When, however, we consider that what *we* see in a star and what a sensitive dry plate sees are quite different things, it is at once evident that photographic magnitudes are not always strictly comparable with visual magnitudes.

The blue end of the spectrum and the ultra-violet most affect a dry plate, while our eyes give greater value to the orange and red end of the spectrum, and it is impossible to make our plates exactly take the place of eyes even by the use of colored screens and orthochromatic plates. Still photographic estimations of the stellar magnitudes have their value since the results in the case of bright stars follow very closely the visual estimates, and in any case we have a record of the relative standing of the stars observed as regards the blue and ultra-violet rays they emit.

Photographic magnitudes are estimated in different ways. The first is by observing the effects of irradiation. To make this method clear to you consider an analogy.

If I throw a small stone into a pool of soft mud it will make a little splash. If I throw in a large stone it will make a big splash, and stir up the mud in a much wider circle than did the little one. Now weak light and strong light produce much the same effect on a photographic plate as did the stones on the mud.

Most view photographers have had good pictures of interiors spoiled by the strong light from some window making a "halo" round about the window frame. A point of light from a star acts in the same way, and if the exposure is long enough the light is reflected from particle to particle of the emulsion in such a way that the star image is enlarged to a circle. It is evident that bright stars make a greater splash, as it were, on the plate than faint stars, and so by measuring the diameters of these images we can estimate the relative photographic magnitudes of the stars that made them.

Another plan is to move the plate slightly inside the focus of the lens, giving the star the appearance of a luminous disk. The luminosity of these disks will vary, of course, with the brightness of the stars observed, and by measuring the opacity of the silver deposits formed on the plate the relative magnitudes of the stars observed may be estimated.

The usual method of observing is to photograph the desired stars when they are at the altitude of the pole and then on the *same* plate, and with the same exposure photograph the pole star and a certain sequence of standard stars around it. The standard stars and stars to be observed are easily identified by taking separate photographs of each, superimposing these on the double-exposed plate and marking the desired stars. The double-exposed plate may now be examined and the magnitudes of the observed stars estimated by comparison with the stars of the standard sequence.

Attempts have been made to secure an absolute scale of photographic magnitudes. You will have noticed that in the above method the magnitudes are obtained by comparison with stars of previously determined magnitudes. This is not always a very convenient method, and besides some day our standards may have changed their brightness. If, therefore, we can adopt a standard of comparison which can at any time be reproduced by laboratory experiments a great advance has been made, for any observer in the distant future can always compare our determination of magnitudes with his own, as the possession of the data is all that is necessary to the reproduction of the standard.

Messrs. Parkhurst and Jordan, of the Yerkes Observatory, have recently tried a method of obtaining absolute magnitudes with much success.

Their process was to illuminate different parts of a photographic plate with the light passing through a number of holes varying in size in a regular ratio and representing differences in illumination expressible in stellar magnitudes. Plates have been produced in this way, and by comparing them with one of Pickering's photographic wedges the absorption curve of the wedge could be plotted and the wedge scaled in stellar magnitudes. Star images are then photographed out of focus and the plates compared in a photometer with the wedge and the magnitudes of the stars determined according to the effect their light had had on the plate. The effect of the stars on the plate is thus comparable with the light passing through holes of different diameters.

This sounds quite simple, but in that it is like a great many other astronomical observations, which are very

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simple if only rough approximations to accuracy are required, but which require all the refinements ingenuity can suggest to avoid or eliminate errors and secure those extremely accurate results which modern astronomy demands.

The originators of this method deem it useful for the measurement of light curves of variables of the Algol type and of short period variables generally.

In this article the treatment of the subject has necessarily been general rather than specific, as my aim has been to give as complete an outline as possible of the whole subject and to bring together general information now unobtainable by the amateur except by reference to a considerable number of standard works and scattered papers.

The Relation of Light to the Growth of Plants

How Colors Affect Vegetation

By Benjamin C. Gruenberg

IT has long been known that in the carbon-fixation by green parts of plants the red rays of the solar spectrum seem to produce maximum results. This is apparently not due to the difference in wave-length between the blue or violet rays and the red rays, but rather to the difference in the relative energy intensities of the different colored rays used in the earlier experiments. With equal amounts of energy supplied, the green plant will decompose carbon dioxide as readily with light from one end of the spectrum as with rays from the other. These results are, however, partly invalidated by the further fact that it is impossible to measure the quantity of light energy actually utilized by the chlorophyl of a leaf. Since experiments have to be conducted with the live plant, the measurements heretofore have consisted of determinations of the total amount of light falling upon the surface of the leaf. But different tissues of the leaf will absorb different rays in varying proportions, and it is impossible to tell what portion is absorbed by the chlorophyl bodies themselves. These latter contain, in addition to the chlorophyl, other pigments, especially yellow substances that absorb blue and violet rays very strongly. These pigments do not contribute to the decomposition of carbondioxid; a large portion of the blue-violet light is absorbed without being converted into chemical energy.

Most of the investigators who have grown plants under lights of different colors have found a maximum of dry weight addition to the plants in connection with the red and yellow rays of the solar spectrum. One or two, however, have found the maximum production at the other end of the spectrum. According to Dr. W. Lubimenko, of the Imperial Botanical Garden of Nikita, in Russia, this apparent contradiction arises from the failure of earlier investigators to distinguish between the energy utilized by a plant in the decomposition of carbon dioxide and that used in the later stages of carbon fixation. This botanist repeated a number of the earlier experiments, determining in each case the actual amount of carbon dioxide decomposed in a given time.

Lubimenko used colored glasses whose actual color values were ascertained by means of the spectroscope; from these he obtained a complete range of colors from the extreme of the visible violet to rays having a wave length of 0.700μ. As a means of control he used plain white glass, single layers of paraffined paper, and double layers of this paper. As the monochromatic light filters varied as to the amount of light that they allowed to pass through, the glasses were selected by means of comparative spectro-photometric tests and arranged to permit equal illumination for all segments of the spectrum. The amount of light cut off by the paraffined paper was also measured by means of sensitive photographic paper; it required 180 thicknesses of the paraffined paper to shut out completely the light of the sun. The usual precautions were taken as to temperature, sampling, etc. The experiments were carried on in parallel for five different species, namely, radish, bean, pea, nasturtium and carrot.

The results, given in three tables, are summarized as follows:

An examination of the table shows that the maximum production did not in any case coincide with the maximum illumination, the sunlight modified by one or two thicknesses of paraffined paper being more favorable to gain in weight. It was also found that the relation between increase and light varied from time to time in the course of a plant's development. Thus, in the case of the radish, the full light gave the maximum increase during the third week, whereas during the seventh week this gave the lowest increase. Of course the actual differences in weekly gains depended also upon the variations in amount of daylight from time to time.

By comparing the results for the colored lights it may be seen from the table that the smallest gains as well as the minimum of energy absorbed was uniformly from the green light. Under the green glass the plants frequently died before flowering. The red light yielded in all cases a maximum of energy for the decomposition of the CO_2, but, with the exception of the bean, all the plants gained weight more rapidly under the blue glass than under the red.

The anomaly in these results is explained by Lubimenko by assuming that the light plays a double rôle in the work of photosynthesis. A strong light is first active in decomposing the CO_2 and in the synthesis of the first organic product; but the further assimilation of this first product requires a light of lower intensity. The amount of carbon fixation depends upon the energy that effects this assimilation of the materials elaborated by the leaves. Accordingly, the gain in dry weight that a plant makes will be determined by a number of factors in addition to that of light intensity. The chlorophyl apparatus is capable of doing a certain amount of work, but the actual amount of work done will depend also upon the needs of the organism. The amount of work it is capable of doing is far in excess of the needs of the organism.

Lubimenko also thinks it likely that the lights of different wave lengths, particularly the red and the blue, have specified functions in the photosynthetic process. The red rays serve to break up the CO_2 and water, and to recombine the elements into the first organic product. The other rays absorbed during this stage of the process are of no use whatever to the plant. For the assimilation of the organic matter formed into the substance of the plant, there is then needed a light of low intensity; it is here that the blue rays serve specifically. Since it is probable that the chlorophyl is also functional in this stage, the absorption by the chlorophyl of the blue rays is explained.

These suppositions of Lubimenko's are partly in general agreement with what has been long known about the physiology of carbon fixation and of plant growth. Plants exposed to very intense light do not grow as well as they do under moderate illumination. This is shown by the rapid elongation of the shoots of plants kept in the dark as well as by the bending of plants that are illuminated from only one side. The plant in such cases bends toward the source of light, not because "it seeks the light," but because the darker side grows more rapidly than the lighter side. It is not necessary, however, to make the further assumption that the chlorophyl apparatus participates in the assimilation of the carbohydrates, or that light is essential to the process. It is a well-known fact that plant cells supplied with nutrition will continue to form new tissues in the dark. This is seen not only in the growth of underground portions of plants or of growing layers under the bark of trees, etc., but also in the case of plants kept in absolute darkness, but supplied with nutrients.

Illumination.	Radish.		Bean.		Pea.		Nasturtium.		Carrot.	
	Energy Taken Up	Increase in Dry Matter.	Energy Taken Up	Increase in Dry Matter.	Energy Taken Up	Increase in Dry Matter.	Energy Taken Up	Increase in Dry Matter.	Energy Taken Up	Increase in Dry Matter.
White Light— Full illumination	100	100	100	100	100	100	100	100	100	100
One thickness of paper	88	116	90	119	91	108	82	143	82	101
Two thicknesses of paper	66	128	74	108	77	101	72	148	77	135
Colored Light— Red	22	5	16	25	34	30	37	15	20	4
Orange	18	2	9	12	21	22	30	9	17	..
Green	1	0	1	0	2	0	4	3	0.2	..
Blue	18	6	13	23	22	41	24	29	16	7

As a basis for comparing the relative amounts of energy taken up in the decomposition of CO_2 the actual quantity of the gas decomposed was determined. For each of the seven conditions of light a specimen was prepared in a vessel containing a mixture of air and CO_2, having from 10 to 12 per cent of the latter. These were exposed to the sunlight, and the amount of CO_2 remaining in each vessel at the end of one hour was ascertained. The five species of plants experimented upon differed among each other with respect to the quantity of CO_2 decomposed in an hour by a given amount of leaf tissue exposed to direct sunlight, from 62.7 volumes in nasturtium, to 97.6 in the case of the carrot.

To determine the increase in dry weight, samples were taken from each lot at intervals of several days and the gain found by actual drying and weighing.

According to the theory of Baeyer, carbohydrates are formed by the polymerization of formaldehyde which results from the decomposition of CO_2 and water. In accordance with this theory experiments have been made to determine whether a green plant can derive any nutriment whatever from formaldehyde. Bokorney succeeded some three years ago in getting water cress to grow under a glass jar over a solution of caustic soda containing small amounts of formaldehyde—that is to say, in an atmosphere free from CO_2. Indeed, in this experiment the assimilation actually proceeded without oxygen and without light!

It is possible also that the amount of CO_2 that disappeared in these experiments of Lubimenko's is no certain criterion of the energy absorbed by these plants under normal conditions. That is, the fact that CO_2 was present in such large excess may have led to its decomposition out of proportion to the power of the plant to make carbohydrates. At any rate, it is possible to interpret these figures without assuming a specific function for the rays of short wave-length.

These results are not in complete harmony with those obtained from some experiments on sugar production carried out in Idaho during the past two years (Sci. Am. Supp. No. 1834, last page), where the maximum growth and productivity was correlated with the highest illumination. This disagreement may be explained as due to the specific susceptibility or tolerance to light exhibited by different kinds of plants.

Cathode Rays in Telephotography

CATHODE rays are deviated by a magnet instantaneously. This fact has been utilized by Dieckmann and Clage in the construction of a telephotographic receiver destitute of inertia. A pencil of cathode rays is defined by a diaphragm having a fine perforation. This pencil is acted upon by two pairs of electro magnets which displace it in two mutually perpendicular directions, and which are operated by two current components determined by the movement of a stylus at the transmitting station. The result is that the pencil of cathode rays imitates every movement of the stylus instantaneously and thus produces, in a plate of chalk or other fluorescent material, a luminosity which appears to the eye as a continuous line comprising all the successive position of the luminous point. In the construction of the transmitter an artifice which has long been used in telautography is employed to resolve the motion of the stylus into rectangular components and to translate these into current strengths.

The following modification of the process has a certain practical importance. The electro magnets, operated by a small dynamo provided with a voltage regulator, are so arranged that they throw the pencil of cathode rays into regular oscillation in a vertical plane. Each vertical oscillation is followed by a small horizontal displacement, so that the phosphorescent point describes a series of parallel lines very close together. In this way the phosphorescent point explores, in about 1/10 second, an area 3 centimeters (1.2 inches) square. In consequence of the persistence of impressions on the retina, the entire square appears luminous. The transmitter contains a square of the same size, which is explored successively by little metallic brushes in synchronism with the receiver. These brushes are connected to one pole of a battery, the other pole of which is connected through the line wire to two coils which serve to deflect the cathode rays at the receiving station. The other ends of these coils are grounded. A pattern or stencil of sheet metal, connected to earth, is laid on the transmitting square beneath the little brushes which as they traverse every part of the pattern, close the circuit, so long as they rest upon the metallic portions. When the circuit is closed, the cathode pencil is deflected, so that it does not fall upon the receiving screen, consequently the phosphorescent point traces on the screen only those areas which correspond with the cut-out portions of the stencil. The whole operation is repeated indefinitely and consequently the picture can be viewed as long as desired. With this arrangement each element of the image is produced in 1/5000 second. The inventors of this process intend, if possible, to utilize aerial electric waves for transmission, in order to eliminate perturbations due to conductors.—*La Nature.*

Recent Finds in Archæological Research

IT is reported from Naples that during the recent excavations at Pompeii, there was discovered the petrified body of a young woman upon which were jewels of great value. Among these are braclets and necklaces and other jewels, showing that this must have been a person belonging to the patrician class. Two earrings, each composed of 21 pearls arranged in clusters, were especially remarkable. Besides their intrinsic and artistic value, they have a great interest from an archæological standpoint, as no others of the kind have been found at Pompeii. We also note that at Brescia there were lately discovered the remains of a small necropolis of the Roman epoch, and up to the present 22 tombs are uncovered. These date from the time of Augustus. They contained no human remains other than dust, however, but some interesting objects were found, among others, vases of different forms and bronze necklaces of fine workmanship. All these objects are well preserved.

The Natural Tunnels of Laos

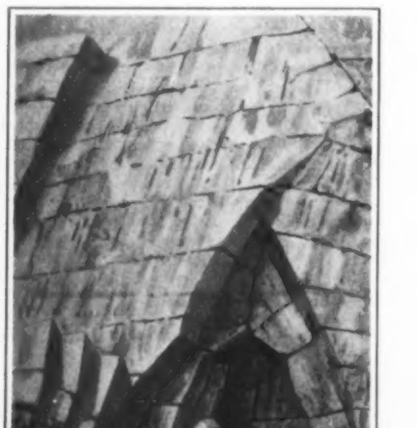
A Chinese Subterranean Watercourse

Cammon, a province of Laos, in French Indo-China, contains many extensive beds of ancient limestone, bordered by dikes of lava, which in several places have been perforated by mountain torrents in their impetuous descent to the Mê Kong river. There are seven of these natural tunnels or subterranean watercourses, having an aggregate length of about 12 miles, half of which has been explored by M. Macey, of the French

DOWN-STREAM MOUTH OF THE NAM HIN BOUN RIVER TUNNEL

colonial administration, who gives an account of his researches in a recent issue of *La Nature*. The chain of these tunnels, having a total length of more than 4 miles, through which the largest stream flows, and the subterranean portion of the smallest stream, more than one mile in length, are still entirely unexplored. The tunnels of the streams Sê Bang Fai (2½ miles long), Nam Hin Boun (2½ miles), and Houci Khi Heup (1¼ miles), have been completely explored.

In August, 1904, a government steamer ascended the Sê Bang Fai to the down-stream mouth of the tunnel, 155 miles from the Mê Kong, where a bamboo raft was constructed for the exploration of the tunnel. March was selected as the most favorable season for the exploration, as the stream was then lowest. In the shallower parts of the tunnel the depth of water varied from 2½ to 5 feet, but in some of the depressions it was 26 feet. In places the stream was bordered by banks of sand or rock on which the explorers could walk, with some difficulty, towing the raft with a rope. Once a flood caused by a heavy rainstorm suddenly raised the level of the stream more than three feet and in a few minutes carried the raft several hundred yards down stream, undoing an hour's hard work. The storm continued 24 hours, and three days elapsed before the water had subsided sufficiently to allow the explorers to proceed. Several rapids were also encountered. Twenty-one hours of actual progress (in addition to the three days halt) brought the party to the double mouth of the tunnel. The lower opening was nearly submerged and the explorers made their escape by a perilous climb through the upper and larger passage. These openings are surprisingly small in comparison with many sections of the tunnel. Extremely high floods had left their marks on the face of the cliff 65 or 70 feet above the water, or



DOWN-STREAM MOUTH OF THE SÊ BANG FAI RIVER TUNNEL

about 35 feet above the top of the upper opening. At this point the river is about 250 feet wide and is bordered by nearly vertical cliffs which extend upstream more than a mile on one side, but only 200 yards on the other. Its source is some 50 miles distant.

The course of the Nam Hin Boun River is entirely confined to the alluvial plain of the Mê Kong, and bends at a right angle in its underground part. This tunnel is frequently used as a subterranean waterway by the natives when the water is low. In the rainy season it is made impassable by a seething torrent which makes a terrific noise. In its underground course of 2½ miles the stream descends more than 100 feet by several rapids, which make portages necessary, even in going downstream. The voyage is made in light canoes, with bundles of bamboo attached to their sides, and occupies about 2½ hours in descending, and an entire day in ascending. The tunnel is very irregular in height and width, and exhibits a great variety of curves, straight lines and bends. At low water the greater part of the journey can be made on foot, on the sand banks and ledges of rock that border the stream, but the path is so rough that boats are generally preferred, even in going upstream, and the banks are used only at portages.

The Houci Khi Heup is a small stream, only 7 or 8 miles long, which traverses a bed of limestone by a tunnel about 1¼ miles long, near its confluence with the Nam Hin-Boum. This tunnel, which was explored in 1902, is the most interesting of all, and no description or picture can give an adequate idea of the varied and majestic beauty of its masses of stalactites and stalagmites. In the dry season the depth of water varies from 16 inches to nearly 7 feet and part of the journey must be accomplished by swimming. In times of flood the water is 10 or 12 feet higher and the descent almost imperceptible, so that the tunnel can be traversed in canoes without any difficulty. The mouth by which the stream enters the tunnel is 65 feet high and 100 feet wide, but it is partly closed by a mass of rock, fallen from the cliff, so that the stream, which formerly divided into two branches inside the tunnel, is now confined to one of the channels. In floods some water forces its way into the other channel and flows on until it is stopped by a huge column of rock. This column is perforated

THE SUBTERRANEAN COURSE OF THE SÊ BANG FAI RIVER

by a bent passage about 7 feet in diamater, but the floor of this passage is several yards higher than most modern floods, so that the water is stopped at this point, except in extremely high floods. The explorers walked, and even led horses, through this passage. At the same point is an obliquely ascending passage which extends to the surface of the hill above. The stream emerges from the tunnel through a modest arch about 25 feet high. This tunnel of remarkable form and beauty can be traversed on foot in less than an hour, in the dry season, and by boat in a few minutes, in the rainy season, but several days may be enjoyably spent in exploring and studying its ramifications and lateral caverns.

Will Mankind be Compelled to Starve?

The threatened exhaustion of the world's supply of coal, wood and iron is less alarming than the possibility that the earth may at no very distant epoch become unable to supply its greatly increased population with food. Already Great Britain and, to a smaller extent, Germany and some other countries, are dependent upon the importation of grain. What can be done when this resource shall fail because the earth, as a whole, cannot produce sufficient grain for its needs?

At last year's meeting of the British Association for the Advancement of Science, in Winnipeg, the center of the Canadian grain trade, Major Craigie presented statistics of alarming import, showing that the population of Eastern and Central Europe has increased from 167 millions to 267 millions in the last 70 years, during which the area devoted to grain raising has actually diminished. In the years 1901-1905 the proportion of domestic production to consumption of grain was 20 per cent in Great Britain and Holland, 23 per cent in Belgium, 64 per cent in Germany and 80 per cent in Italy, and these countries annually imported more than four hundred million bushels of wheat. About half of this quantity came from Russia and other Eastern countries. As the average yield of wheat in non-European countries is only from 10 to 20 bushels per acre, an area of ten to twenty million acres was required to produce their exports to Western Europe.

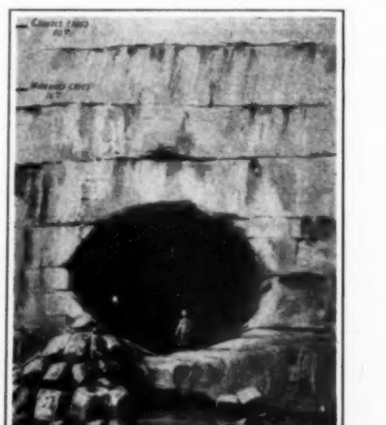
In the last 10 years the proportion of the land devoted to wheat culture has decreased from 25 to 20 per cent in Belgium, from 28 to 25½ per cent in France, from 12 to 10 per cent in Great Britain, and has increased only in Eastern Europe. In Roumania, between 1886 to 1906 the percentage of wheat land increased from 25 to 72, and the yield per acre rose from 15 bushels in 1890 to 19 bushels in 1906 and 23 bushels in 1908. In Hungary the wheat acreage increased from 7 to 9½ millions, between 1886 and 1906. It has since fallen a little, while the yield per acre has increased.

DOWN-STREAM MOUTH OF THE HOUCI KHI HEUP RIVER TUNNEL

In France the wheat acreage decreased slightly between 1884 and 1908, but the yield per acre has risen in the last five years from 17.8 bushels to 20.2 bushels, more than compensating the reduction in acreage. The problem is less acute in France than in some other countries, as the population is not increasing. In Germany, where 4.7 million acres are planted with wheat, the yield per acre increased from 20.3 bushels in 1889 to 27.9 bushels in 1903, and has since risen apparently to 30 bushels, although this last increase may be partly due to a change in the statistical method.

In a recent issue of *Ueber Land und Meer*, Dr. Ernest Schultze quotes these statistics from Craigie's address and goes on to say that Western Europe would feel the pangs of hunger if the importations of grain from non-European countries were cut off. Furthermore, although the wheat production of the United States has increased enormously in the last thirty years, the population, and consequently, the consumption of wheat, have increased still more, so that a smaller part of the crop is available for export. In recent years Canada has become an important factor in wheat production. Contrary to expectation, the climate of the Canadian West has proved especially well adapted to the cultivation of wheat and the virgin soil of the vast prairies yields very large crops. But even these prairies are not unlimited and their fertility will soon be exhausted if the destructive American methods of cultivation are followed.

The United States and Canada, however, are not the only countries capable of producing wheat. They have already found a formidable competitor in Argentina, of whose vast area 12 million acres were planted, chiefly with wheat, in 1908. Argentina possesses 158 million acres suitable for grain production, 16 times the area now utilized. There are other countries which are



UP-STREAM MOUTH OF THE SÊ BANG FAI RIVER TUNNEL

capable of producing large quantities of grain. The wheat fields of Australia already comprise 6 million acres and the average annual exports, from 1903 to 1907, amounted to 36 million bushels. Siberia, whose climate, like than of Canada, was long misunderstood, is entering the light of grain producing lands. The production of grain can be greatly increased in Asia Minor, Mesopotamia, Sicily, Spain, North Africa and many other

regions, which in ancient times were called the granaries of Europe. Even Russia is far from being completely under cultivation. Immense quantities of grain can be produced in Manchuria, in India (with irrigation), on the table lands of Central Africa, and elsewhere. All of these lands, even if they yield only 12.7 bushels per acre, which is Sir William Crookes' estimate for the present wheat fields of the world, will supply food for a vastly larger population than the world now contains.

But the question of a possible shortage of wheat occurring within a comparatively short time cannot be dismissed so easily. Two years ago Prof. Silvanus Thompson predicted that this shortage would be felt in 1921, ten years hence. His prediction was based on the following considerations: The present wheat fields of the world comprise 240,000,000 acres and produce 3,000,000,000 bushels annually. The annual consumption of wheat is equivalent to 4.5 bushels per capita of the wheat-eating population. Hence the average wheat crop is sufficient for 660,000,000 persons. The wheat-eating population, including the white race and a few fragments of other races, already numbers 585,000,000, and Prof. Crookes has estimated that in 1921 it will have increased to 671,000,000, 11,000,000 more than the present crop can supply. In 1941 the white race will have increased to 819,000,000.

Thompson, however, overlooked the fact that the yield per acre can be increased, and that it has been increased in many regions, as the population has became denser and land more valuable. In the nineteenth century the area of the wheat fields of Germany was doubled and the yield per acre increased seventy per cent, so that the annual wheat production at the end of the century was nearly three and one-half times what it was at the beginning. The increase in the yield per acre between 1899 and 1903, already mentioned, shows that the maximum crop has not yet been attained. The improvement has been brought about by more rational methods of cultivation, selection of seed, increased use of fertilizers and the introduction of machinery, and still better results will yet be obtained.

It is certain, then, that the world's wheat crop can be greatly increased, and it is equally certain that the increase will be produced almost automatically as the value of land rises. This process, which was strikingly illustrated in the nineteenth century, is now taking place in the United States, beginning in the east and gradually progressing westward. The American farmer is being compelled to cultivate a few acres well, instead of cultivating many acres poorly. The process will be repeated, later, in Argentina, Siberia, and other wheat-producing countries.

No wheat famine, therefore, is likely to occur within the next few decades, but no man can predict the conditions that may prevail at the end of the twentieth century.

A New Wireless Transmitter

The Lorenz System Briefly Described

The Lorenz company has constructed a new direct current wireless transmitter, the description of which will be made more intelligible by a recapitulation of what has already been done in its special field. The review and description are condensed from an article by Dr. G. Eichhorn, in the *Illustrite Zeitung*.

In 1906, undamped or sustained electric oscillations, produced by Poulsen's arc device, were first employed in wireless telegraphy. A receiver with minimum damping then became a desideratum, and the Poulsen-Pedersen "tickler" was found to give a remarkable and previously unattained facility in tuning and freedom from disturbance. Then came from America the method of increasing the sparks of the ordinary spark-transmitter to such an extent that they throw the telephone membrane of the receiver into regular vibration and produce a musical sound which can be clearly distinguished from the effect of atmospheric disturbances in many cases, and even from other wireless signals in favorable conditions. This idea was taken up by Gesellschaft fuer drahtlose Telegraphie. Poulsen had already devised a method of dividing his undamped oscillations into equidistant groups, which produce a very clear and easily varied and regulated tone in the receiver. This method has hitherto been employed for short distances only, owing to the want of an interrupter suitable for use with very strong currents.

The same advantages are possessed by a method of

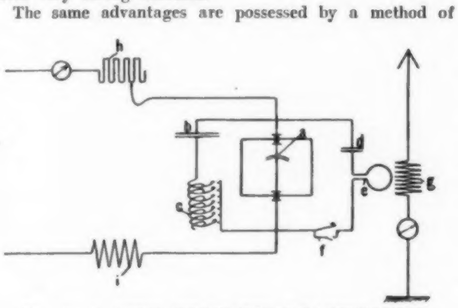


Fig. 1.—A NEW WIRELESS TRANSMITTER

producing the oscillations by causing two oscillating currents, each including a luminous arc generator and slightly out of tune with each other, to act upon a single antenna circuit. Oscillations produced in this way also evoke very clear and distinct tones, the pitch of which can be conveniently regulated, but only at comparatively short distances.

Two expedients have been tried for the purpose of increasing the range. In one system the arc circuit is traversed by a direct current and also by an alternating current, which periodically influences the oscillations produced by the arc. In the second system the arc is replaced by a short spark-gap and the direct current is reinforced by an alternating current, furnished preferably by a Duddel oscillatory circuit, by modifying which the pitch of the sound produced can easily be varied. This system is especially well adapted for portable stations. The arrangement of the transmitting apparatus is shown in Fig. 1. The spark gap *a* is formed by two electrodes of nearly spherical curvature, one convex, the other concave, the distance between which can be varied. An atmosphere containing hydrogen can be maintained between the electrodes by letting fall between them, by means of an automatic dropper, drops of alcohol, which are instantly volatilized. The Duddel circuit contains a large condenser *b* and an inductance coil *c*, having a core composed of strips of thin sheet iron. This coil is divided into a number of sections, which can be opened or closed separately for the purpose of varying the self-induction of the coil. Connected in parallel with the spark-gap and the Duddel circuits is a third, called the impulse circuit, containing a small condenser *d*, a key *f*, and a few turns of wire *e*, which act by induction on the coil *g* of the antenna circuit. The discharge through the spark-gap is regulated by the variable resistance *h* and the adjustable choking coil *i*. This discharge is triple, being composed of the direct current from the dynamo or battery, the low frequency a ternating current of the Duddel circuit and the high frequency current of the impulse circuit. The first and second components combine to form an alternating current which produces periodical variations in the resistance of the spark-gap. When this resistance is high a series of high frequency unidirectional discharges from the antenna is produced, but when the resistance of the spark-gap is low and the current through it is a

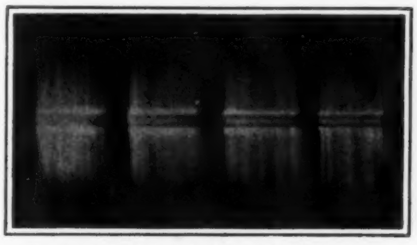


Fig. 2.—GROUPS OF PARTIAL SPARK DISCHARGES

maximum the antenna circuit remains unaffected. The effect of the introduction of the Duddel circuit, therefore, is to interrupt periodically the flow of high-frequency discharges which would be emitted by the antenna and thus produce, in the receiving telephone at the distant station, a continuous tone having the pitch of the Duddel circuit.

The apparatus is very light and its operation is exceedingly simple. By manipulating the contacts of the sections of the inductance coil *c* and leaving the key *f* closed, various tones can be produced, and trumpet call signals and even melodies can be transmitted. Morse signals can be transmitted in any of the possible tones, by manipulating the key *f*. The voltage employed for the spark-gap does not require nice adjustment, the inductive connection between the impulse circuit and the antenna admits of wide variation, and these two circuits need not be accurately in tune with each other.

Four groups of high-frequency discharges through the spark-gap, alternating with intervals of darkness, are illustrated in Fig. 2, while Fig. 3 shows the last four discharges of a group and Fig. 4 the first discharge of the succeeding group.

Toncan Metal

By F. M. English

The development of Toncan metal was undertaken to meet the demand for a black or galvanized sheet which would be moderate in price and have the highest corrosion resisting qualities for use in roofing, siding, eaves trough, conductor pipe, and for all other building purposes into which such sheets enter.

In undertaking the development of a sheet of this character, the manufacturers have been guided throughout by

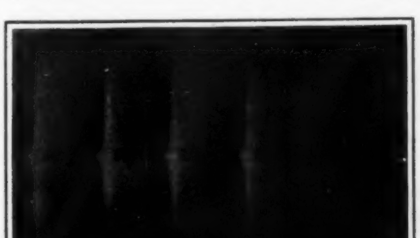


Fig. 3.—THE LAST DISCHARGES OF A GROUP

the old-time iron master and by adapting old-time principles to modern methods as far as possible.

The problem of the iron master in making the quality of sheet which he did was infinitely simple as compared to the one facing the modern iron or steel maker, who undertakes to reproduce sheets having the corrosion resisting qualities of the old-time goods and which also combine all the other qualities requisite in a sheet which must meet modern requirements.

Had we to-day the same raw materials, the same workmen, the same furnaces and exactly the same conditions, sheets could be made in all respects equal to any that have ever been made, but could the manufacturer with such facilities begin to supply the present enormous demand, and could he reproduce sheets at a price which would permit of their use in the vast variety of ways in which sheets are now being utilized?

To meet the present day demand for sheets—to enable the mills to keep pace with the ever-increasing consumption, because of the infinite variety of ways in which sheets are being employed—the slow, limited, methods and processes of the past cannot be employed or reinstated.

The problem now confronting the sheet manufacturer is how to make sheets having the old-time corrosion resisting qualities together with the necessary working qualities, and at a price which will not curtail their use. And it is no easy one. In other words, the sheet manufacturer must now "make a dozen blades of grass grow" where one grew formerly, not at the same price and of the same quality, but at a lesser price and of better quality and with higher labor, inferior raw materials, and to withstand much more exacting conditions.

The conditions to which sheets are now subjected as compared with earlier times are also entirely different—

Fig. 4.—THE FIRST DISCHARGE OF A GROUP

the demands and requirements of trade are far more exacting. The sheet of to-day, to meet modern exactions, must have not only the highest corrosion resisting qualities, but they must have working qualities also, and be able to withstand strains and stresses in shaping, forming and handling never dreamed of in the past, to say nothing of the vastly changed atmospheric demands to which they are now subjected. The sheets of the present time, to meet all requisitions, must be better than the old-time ones, and not only better, but cheaper.

In placing this new rust-resisting metal on the market as a material in which are combined all the qualifications necessary in the modern sheet, whether galvanized or black, it is classed as a metal rather than as an iron or steel, because, while it has corrosion resisting qualities equal to the old-time iron, it also combined many characteristics of the highest grade mild open hearth steel, making it the ideal material with which to meet all requirements of the latest sheet metal practice, in that it will not only withstand corrosion, but also the strains and stresses of shaping and forming without fracturing.

It is an undisputed fact that the corrosion-resisting qualities of the early sheets were due entirely to their uniformity or homogeneity, which was made possible by the proper selection of raw materials through the principle involved in their handling and through the care and attention with which the iron was made. Plenty of time was given with the raw materials while in the furnace, to eliminate any excess foreign impurities present and to properly combine those remaining and also by handling the iron after it came from the furnace in such a manner that segregation did not take place during the reheating or working up processes.

Through modern research and investigation we know that corrosion is caused by the carbon, sulphur, phosphorus and manganese becoming segregated, during the process of manufacture, this theory having been fully demonstrated both in the laboratory and under actual

working conditions—the corrosive action taking place in the following manner:

When the impurities—carbon, sulphur, phosphorus and manganese—become segregated in iron or steel, that is when they are not equally and evenly distributed throughout the metal, occurring in small spots or areas, an electrical current will be set up between these segregated points whenever the sheet, in which they are present, becomes covered with a film of moisture from the atmosphere. Due to differences in composition, some of these points of segregation become positive, others negative, which when connected by the film of moisture, set up numerous electrical batteries of greater or lesser energy, according to the extent of the segregation, so that there are limitless numbers of small electrical batteries continually at work throughout the sheet. It is a well-known fact that a current of electricity cannot be generated in a battery without destruction or dissolution taking place at the positive pole, so that in any sheet iron or steel in which segregation has taken place and the surface of which, through exposure to the atmosphere, has become covered with a film of moisture, there are numerous small electrical batteries at work, at the positive poles of which the iron or steel is being destroyed, resulting in the form of corrosion known as pitting, a form with which manufacturers are all only too well acquainted. The more marked or strongly defined is the segregation, the stronger will be the electrical action; consequently the more rapid will be the destruction of the metal or sheet. On the other hand, the less well-defined the segregation, the weaker or milder will be the electrical action, and consequently the life of the sheet will be longer. Again, in a well-made sheet of iron or steel in which the impurities have been properly incorporated and segregation reduced to a minimum, the electrical action will be so slight that pitting will not take place, but instead an even coating of rust will be formed over the entire surface of the sheet in such a way that the rust will itself become, to a great extent, a protective coating, greatly retarding the process of decomposition or rusting. It was for this reason that the old-time iron sheets withstood so phenomenally the ravages of corrosion. It was not because they did not rust that caused them to last, but the way in which they did rust that made them so long lived.

No iron or steel has ever been made or can ever be made that will not rust in moist air; because it is the nature of all products made from iron ore to rust and in time return to the natural state from which they originally came. But the way in which the rusting takes place can be controlled, thus making the sheet long lived, durable and the most ideal metal for roofing, siding, eaves trough, conductor pipe and other similar purposes.

It has generally been supposed that steel corrodes faster than iron, also that pitting is confined entirely to steel, but this is by no means the case. Both iron and steel pit and corrode, and badly made iron, of which we are getting a great deal to-day, lasts no better than badly made steel. The opposite of which is also true, namely, that properly made steel will withstand corrosion and pitting equally as well as iron, besides having far superior working qualities.

There may possibly be some question as to how electrolysis takes place in causing corrosion as regards the exact chemical reactions; but that electrolysis actually does take place, and that it is the true cause of corrosion cannot be successfully disputed. The fact that electrolysis does occur is proven conclusively by the ferroxyl test, exhibits of which all manufacturers have examined. The object of this test is not to show the comparative lasting qualities of two or more pieces of metal, but only to prove the theory of electrolysis by practical demonstration.

The explanation of the test is this: At the poles of all electrical batteries two elements are always found to be present, namely, hydrogen ions and hydroxyl ions. The hydrogen ions cluster around and indicate the positive pole. The hydroxyl ions in the same manner indicate the negative pole. The ferroxyl testing reagent is composed of certain indicators, the reactions of which when brought into contact with these two elements, have been known for years. Ferroxyl is a weak acid, and is of such a nature that when brought in contact with hydroxyl ions it at once produces a pink color, while potassium ferricyanide, when hydrogen ions are present, causing iron to be dissolved or corroded, produces a blue reaction. Both of these chemicals are present in the gelatine mixture, in which are embedded the samples which you have examined, the blue color indicating the positive poles where destruction or corrosion is taking place, the pink color indicating the negative poles. No piece of iron or steel has ever been found which, when subjected to this test, will not sooner or later develop the pink and blue reaction, which all have witnessed.

The point involved, then, in the manufacture of iron or steel which is to resist corrosion is to so combine and work up the raw materials that these electrical currents, which cause corrosion, will be of the mildest form and whose action is not concentrated or fixed through excessive segregation.

Of the many subjects which are of interest to the sheet metal worker and the user of sheets there is none of such vital importance as the subject of corrosion, and what affects the sheet manufacturer, so that the cause and cure of corrosion is of common interest to both.

If the sheet metal business is to grow, expand and assume the position in the world of business which it should, it is absolutely necessary that the sheet metal workers strive in every way to use only such sheets as will stand up for at least a reasonable length of time and to avoid wherever possible the use of goods that will prove disastrous to his business and his reputation. Manufacturers of sheets have long recognized this fact, and for a considerable time a company at Canton, Ohio, has been carrying on a series of exhaustive tests and experiments to produce a material which would be reasonable in price and meet all requirements—both as regards corrosion resisting qualities and working qualities—thus placing within reach of every worker of sheets a material with which to combat and overcome the ever increasing prejudice against sheet metal for building purposes, a prejudice which has, of late years, been steadily increasing, due to the unsatisfactory lasting qualities of a large majority of the materials which are now on the market.

The result of these efforts is rust-resisting metal, a material which combines the essential qualities of high corrosion resistance, ductility, and moderate cost. A long series of acid, salt and creosote tests have been carried on in addition to carefully noting results of exposure to actual every-day working conditions.

With the necessarily incomplete outline of the qualities and characteristics of this rust-resisting metal, and of the subject of the corrosion of iron and steel, we leave the subject, hoping it will receive from the sheet metal worker the further consideration which is its due. The subject is certainly one of vital importance to every sheet metal worker, because the development and growth of the industry will be determined largely by the degree in which corrosion is manifested in the materials adopted and used. The employment of highly corrosive material will retard and lessen the demand for the sheet metal work, while the use of better and more lasting material will stimulate and encourage the demand.

The Aggregation of Power Systems*

Economic Limitations of the Big Power Station

By Robert A. Philip

Limitations on the distance to which power can be transmitted electrically have been investigated from time to time. In this paper it is the purpose to point out that the limiting distance of transmission is not the limit of economical interconnection and that there is probably no such limit. It is also the purpose to outline certain principles of electric transmission which indicate the line along which unlimited extension of electric net works may proceed.

Electric power promises to become the universal power of the future. It is not a substitute for steam power or water power; it competes with no prime mover. Electric power is essentially a secondary power. Prime movers produce useful but crude mechanical power from the rough, irregular forces of nature. Mechanical power, transformed and refined in the electric generator, becomes electric power, the highest known form. The highest form because it can be changed to other forms, heat, light, motive power, chemical action with unparalleled directness and simplicity. It is the uniform method of applying any kind of power from any source to any work. To other powers it stands as a common medium of exchange. Prime power is like property, electric power like money.

The electric motor consumes electric power produced by an electric generator driven by a prime mover. When an electric motor is substituted for a steam engine the load is merely transferred from one prime mover to another. There is a loss of power in the electric generator, a loss in the electric transmission line and a loss in the electric motor. In spite of these losses electric transmission and distribution of power is commercially successful because of economy, flexibility and cleanliness.

The motor is economical merely because the prime mover on which it ultimately depends is still more economical; that is, electric power is an advantageous means of producing competition between different prime movers and thereby displacing those that are wasteful. Every circumstance unfavorable for economical power generation can be found in varying degrees among isolated plants while central electric generating plants may take advantage of every practicable economy. Certain highly important differences favorable to centralized prime movers are greater size, greater diversity factor, greater load factor, convenient location for fuel and water and cheap land. Of these some are automatically cumulative. As the plant grows its economy increases, and as the economy increases it surpasses that of more and larger isolated plants, displaces them and thereby grows some more. Furthermore, electric power is not limited to bringing a large prime mover in competition with a small prime mover of the same kind. It goes farther, taking for its source any other kind of prime mover which may be more economical. The economy of electric power is essentially progressive and is only limited by that of the best prime mover of any size, any kind, anywhere.

Power is used to produce results. The requirements for economical production and economical application of power are antagonistic. Concentration and continuity are essentials for favorable production, while subdivision and controllability best adapt it to its uses. Electric power reconciles these diverse requirements. While concentrated at the continuously running generator, it is subdivided at the intermittently running motors.

Essentially a secondary power, it consumes no raw material and emits no waste material. No water or fuel goes in, no ashes, water or gases come out. Increased human activity and efficiency require and depend on increased power, per capita, per square mile, per cubic yard. Contamination of the air by prime movers sets an artificial limitation to beneficial concentration. Electric power removes the limitations and opens up new possibilities. The modern city subway can be operated by electricity and by that alone.

The principle underlying the success of electric power is that of uniformity. Incidentally, to be uniform, the method must be indirect. The same principle underlies the use of money. Property may be exchanged directly by barter, but the uniform method of indirect exchange by purchase and sale is superior. In each case the intermediate medium of exchange gives the flexibility necessary for equalizing production and consumption on a large scale. The public service corporations which distribute power have a function analogous to a banking system. They constitute clearing houses for balancing the individual increases and decreases of power requirements of a community as a whole and provide a centralized reserve for meeting promptly any total net increase.

The power plant which does not use electric power stands alone. In the continual readjustment of industry, there are shifting deficiencies and surpluses of power which cannot be economically met by increasing, decreasing and moving local prime mover power plants. In the aggregate, the disproportion of the isolated prime movers to their loads must be enormous. This leads to the conclusion that there is a great collateral advantage in using electric power, wherever practicable as an intermediate step between the prime mover and the work, thereby providing the necessary means of immediately and without further expense participating in the advantages of uniting resources with the rest of the community whenever emergency, convenience or economy require it.

The success of electric power distribution and transmission has been due largely to two specific applications of the underlying principle of uniformity. First, that it is cheaper to generate power by steam in one large plant than in numerous little plants. Second, that steam power may be economically superseded by otherwise impracticable water powers. These two applications have built up two classes of transmission systems, those from central team plants originating at the large centers of population and radiating into the country where they supply current for railways, light and power in outlying towns and villages; those from water powers starting from the mountains and converging toward the cities. These applications alone, though stimulated by increased consumption and higher price of fuel, may extend the economical radius of transmission, but not indefinitely.

On the other hand, if there is no increase in the economical radius, nevertheless, the continued development which may be reasonably expected along present lines will in time cover the country with high-tension distribution and transmission lines. These lines will form short contiguous but independent transmission systems, each one having a specific function of distribution or transmission which pays for the interest on the investment, the repairs and maintenance and the cost of power used up in core loss and other friction or leakage necessary for keeping the system alive. While each line is useful and necessary, every line is subject to periods when it is idle. In other words, its load factor is low. During off peak hours, power can be transmitted subject to no charge for interest, repairs or maintenance and free of deduction for the constant losses of the system. Devoid of these encumbrances, the usual limitations to the distance to which power may be transmitted do not hold.

This opens the way to a broader application of the principle of uniformity. The differences in economy between large and small steam plants and between steam and water power plants are not the ultimate limitation to transmission. Were the limitations reached in these two directions there remains a vast field of economy in applying the principle in other directions.

Diversity factor alone contains almost inconceivable possibilities. Whenever there is intermittent work diversity factor may be expected. In so far as it is unnecessary to do two different things simultaneously it should be unnecessary to duplicate the power supply. Since the point of application of electric power may be instantly transferred from place to place, only a half (or other fraction, as the case may be) of the prime power is required in a central plant which would be needed in two or more separate local plants. This fraction is the diversity factor. It has already done much to enhance the advantage of the large plant over the small one, but the large plants in turn are governed by local conditions and, like the isolated plants they supplant, they have important diversity factors among their loads. Thus the conditions determining the hour of peak vary considerably in different cities, with the industries and customs of the inhabitants, with local weather conditions, with

*American Institute of Electrical Engineers.

the altitude, latitude and longitude; the artificial convention of standard time makes an hour's difference in time of starting work in nearby cities and over greater distances the natural difference in time makes greater differences.

Water powers have a peculiar species of diversity factor of production due to non-coincidence of deficiencies. While there are dry years in which all water powers may suffer deficiency, the idea of coincident deficiencies is largely due to insufficient and inaccurate records. From the nature of the case the rains, snow fall, freezing and thawing must vary widely according to the location and exposure of the watersheds. There will be some diversity between the flow of any two streams though they be adjoining, a greater diversity between those on opposite sides of a divide, and more between those on different mountain groups. A large river which runs dry for short periods for lack of storage and a large reservoir on a small stream are each defective for power supply, but together they may be mutually supplementary. By combination the bulk of the power may be derived from rivers on one watershed, the reserve storage from those on another.

More remotely the general extension of transmission may open up possibilities of developing the intermittent powers of nature which, variable and unreliable in any one locality, when taken over a large area, or in connection with each other or with existing developments, may be found to be uniform and reliable. Thus the tides occur at different hours and at different points. Variable powers such as the wind have appeared impracticable largely because they have never been studied adequately, and if developed locally, require a prohibitive expense for regulating, equalizing and storage. Comprehensively developed as an auxiliary to an established system which could use the power as available, the cost of power from these sources would be far less than has been heretofore supposed.

Transmission lines are the highways of power. Having made power portable and universally applicable by reducing it to the electric form, it is inconceivable that the highways over which it travels will not be vastly more useful if interconnected.

More definitely, there is the present problem of existing transmission systems growing beyond the bounds for which they have been designed by the annexation of adjoining independent systems as one by one the collateral advantages pass into the domain of accepted fact.

To design a transmission line to transmit power from a water power plant to a city is a definite problem. To interconnect two such lines to accomplish some auxiliary purposes not in the original design is quite a different problem. The interconnection of two transmission systems is like combining two railroads, first, there must be a physical connection, then unified operation. As the gages of the railroads must be reconciled, so the frequencies, phases and voltages must be adapted by reducing to a common standard or the power must be converted at the junction points. Then the flow of power in the network must be controlled so that, within the limitations of the wires provided, power may be transferred at will from points of surplus to those of deficiency. This problem of interconnection differs from that of transmission in introducing as an element the idea of reversible transmission, that is, either end of the line may be generating or receiving end.

The interconnection of two systems forecasts future connection with a third and fourth. Such extension carried on indefinitely, leads to the conception of a single vast system which may be built up in the future. Electric power is successful because it is the one uniform method of equalizing supply and demand. Every extension and interconnection broadens the field in which it can act and should increase its success. Continued, indefinite extension is desirable and inevitable if possible.

As electric power is like a common denominator to which all other power is reducible, so alternating current is the common form to which electric power itself must be reduced to become universally available. Direct current is useful and necessary, but its function, for the present at least, is that of a form auxiliary to or derived from alternating current and limited in the distance which it can travel to a single locality. Alternating current combines a suitability to the high pressure necessary for transmitting power in bulk long distances with a simplicity of division and subdivision both of power and pressure which is necessary for the ultimate distribution. Furthermore, the alternating current system has unique qualities which especially suit it for reversible operation, and thereby adapt it for indefinite extension.

Electric currents are commonly regarded as flowing from points of higher potential to those of lower potential. With direct currents the potential of the generating end of the line must be higher than that of the receiving end directly in proportion to the power delivered in order to overcome the line resistance. With alternating currents delivering the same power over the same line at the same voltage and at unity power factor, the potential of the generating end must be still higher as the reactance as well as the resistance of the line must be overcome even if the power is delivered at unity power factor, which is usually regarded as the most favorable case for alternating transmission. If the power is delivered to an inductive load the power factor will be lower than unity and the potential of the generating end must be higher yet in order to force the magnetizing current over the line in addition to the working current.

To provide for the variation of drop of potential in a transmission line at varying loads numerous devices are used. The generator voltage may be varied through adjustment of the field rheostat or by compounding; the ratio of step-up and step-down transformers may be made different so that the generator voltage will be the same as the receiver voltage at full load instead of at no load, as would be the case if the transformers had the same ratio; or separate boosting transformers may be used to the same end; a regulating dial connected to taps to the transformer windings may be used to vary their ratio, or a regulator consisting of a separate transformer of variable ratio may be used for the same purpose.

While in ordinary alternating-current transmission supplying only lights and induction motors the potential at the generating end is necessarily higher than at the receiving end, in a transmission line supplying a synchronous motor taking a leading current the condition may be reversed and the potential may be higher at the receiving end than at the generating end so that the current flows from a point of lower to one of higher potential.

While leading currents may cause the potential at the receiving end to be higher than at the generating end, they do not do so necessarily. With a large amount of leading current the potential may be higher at the receiving end, but with a small amount it may be lower and with an intermediate amount it may be the same at the two ends and may be maintained the same even if the load varies by a corresponding variation in the amount of leading current.

Power may therefore be transmitted over a line by alternating currents without change of potential and a system may be built up by adding other lines until a network is formed uniting many power houses and many substations. In such a system the potential may be the same at the bus bars of every power house and every substation and yet power may be transferred at will through the network in any direction. Since the potential at the edges of such a network is the same as at the center it is evident that the system is capable of indefinitely great extension. While the power is transmitted without loss of potential there is a loss of energy equal to the square of the current multiplied by the resistance as usual. The possibility of extension is not for the transmission of power in bulk for indefinitely great distances, but rather for the extension of a network containing points of generation at intervals, the load being equalized on the points of generation by means of the network which permits of power being transmitted to or from any point in any direction for distances as great as considerations of emergency or economy may indicate from time to time.

In view of the customary drop of potential from the generating to the receiving end of the line, transmission without this drop may at first seem to be an abnormal and unstable condition, but this is not the case.

Suppose two identical machines connected by a line, one run as an alternator and the other as a synchronous motor. If the resistances and reactances of the armatures are so small as to be negligible and if the strengths of the fields are so great compared to that of the armatures that the effect of armature reaction is negligible, then this combination will automatically transmit the power with constant potential at each end of the line independent of load and of line impedance. If the armatures of the machines have appreciable resistance or reactance there will be a drop of potential from no-load to full load, but it should be noted that the drop results from the resistances and reactances in the machines, not those in the line. It is therefore only necessary to improve the regulation of the machines themselves to attain a natural constant potential transmission system.

To operate a synchronous motor on the constant-potential system we should therefore adjust its field, not according to a power factor meter, but according to a voltmeter on the line, as it is normal line voltage, not unity power factor on the motor, which is desirable. The condition, previously assumed, that the synchronous motor is a machine which is a duplicate of the generator is not essential, also any other kind of load may at the same time be supplied by the same line. Where both synchronous and induction motors are operated from the same line the voltmeter method of adjustment has the advantage of simplicity in that the proper adjustment of the field of the synchronous motor for overcoming the lagging currents of the induction motors is obtained thereby although the currents taken by the induction motors are unknown to the one making the field adjustment. Where synchronous motors are used on lighting systems the advantage of operating them on the constant potential system is obvious, for if correctly operated in this manner the regulation of the system, which is of prime importance, becomes perfect.

Taking again the case of the two-machine transmission just considered. Suppose a mark made on some point of the rotor of the generator and a similar mark at the corresponding point of the rotor of the motor. At no load the marks will reach the top of the circles in which they revolve at the same time, indicating that the voltage of the motor is in phase with that of the generator; as the load comes on, the mark on the motor will fall behind that on the generator, reaching the top position a little later, indicating that the voltage of the motor is falling behind that of the generator. This illustrates the principle that in constant-potential transmission current flows and power is transmitted from points of advanced to those of retarded phase. In other words, the potential of the receiving end must drop behind that of the generating end in phase instead of below it in magnitude.

In a direct-current transmission with constant generator potential the amount of power transmitted increases with increased drop of potential up to a certain maximum and then decreases again, so with constant potential alternating transmission the amount of power increases with increased retardation of potential phase up to a maximum and then decreases again. In each of these cases the range from no load to the maximum load is the range of stable operation, beyond the maximum is a range of unstable operation. In each case, too, the maximum power which may be transmitted depends on the constants of the line. The greater the resistance the less power that may be transmitted by either direct or alternating currents. The analogous assumption that the greater the line reactance the less the power that may be transmitted by alternating current is incorrect. With no line reactance no power could be transmitted at constant potential, but as all lines have some reactance this case would never actually occur. Up to a certain limit the greater the line reactance the greater the maximum amount of power which may be transmitted. For every transmission line there is therefore a range of stable operation for constant potential transmission.

The utility of a system of transmission depends partly on the ease with which its operation can be foretold by calculation. On this basis the constant potential system is at a great advantage, for its characteristics can be shown in a simple diagram constructed from constants which are readily calculated and have an easily understood physical meaning.

The constant potential alternating system is on a par with direct current as to the amount of power and as to the efficiency of transmission over a line of given resistance and voltage.

A comparatively high line reactance is a favorable feature both as regards amount and efficiency of power transmission, and therefore a frequency of sixty cycles per second may be better than one of twenty-five cycles for power transmission.

Reactance makes a line opaque to short circuits, but wattless power introduced at the receiving end makes it transparent to the flow of useful power, therefore the power at short circuit may be less than at full load.

A short circuit may be a local matter not interrupting the service of the system as a whole, not affecting the voltage except for a limited radius, and not draining any extraordinary amount of power from the system.

Switches of limited capacity may be safely used on systems of unlimited power.

Blocks of power too great to be safely controlled may be subdivided by artificial lines instead of being entirely separated.

There are no limitations to amount of phase difference, therefore none to unlimited extension at constant potential, but in distant parts of a large system the difference may be so great that one machine may be one or more complete cycles (or even revolutions) behind another.

In interconnecting different branches of a large system the actual as well as the apparent phase difference must be considered, therefore the readings of any ordinary synchronizing device may fail to indicate the true phase relation.

Constant potential transmission requires controllable leading currents, synchronous motors are the practical source of such currents, therefore the first step in establishing such a system is to have as large a part of the receiving equipment as possible composed of synchronous motors, to have these motors designed for carrying full load with leading currents of say 80 per cent power factor, and to have their voltage controlled by non-compounded voltage regulators.

Rotary converters are synchronous motors, but as ordinarily constructed are poorly adapted for operation with leading currents.

The electrostatic capacity of transmission lines furnishes leading currents which are not directly controllable and are therefore not the equivalent of those from synchronous motors.

Synchronous motors can take lagging as well as leading currents, but the lagging currents taken differ from those of induction motors in being controllable.

The leading currents of line capacity and the lagging currents of induction motors subtract and add respectively certain amounts to the available leading currents to be furnished by the synchronous motors, that is, they do not affect the range of control required, but rather shift the mean position of this range toward lagging or leading respectively.

To summarize the principles here outlined. First is that of the solidarity of the power market as a whole, next is that of the place of electric power in this market which, not itself a prime power, yet is the common medium of exchange for all prime power. From this follows naturally the indefinite extension and interconnection of transmission lines, the highways of power. Underlying all these is the requirement that electric power though poured in unlimited amounts into a system of indefinitely great extent must be as mobile as the trains on the country's railroad network, must be universally uniform in quality, must never be totally interrupted and though in amount unlimitedly great, must not be uncontrollable. To meet these requirements electric power must take the alternating-current form and should be transmitted on the constant-potential system. Finally, this system is one using high line reactance made transparent by leading wattless currents and transmitting power by displacing the phase of the voltage instead of varying its amount.

The governor of the Ubangui and Tchad regions of central Africa has lately issued regulations prohibiting the hunting of the elephant with fire arms and the setting of traps for this animal. The rules also forbid the killing of female elephants and of young immature specimens, whose tusks weigh less than 11 pounds. The elephant in Africa is not domesticated as it is in Asia, and this leads to the indiscriminate killing of the animals in order to secure the spoils. However, under such conditions there is danger that the elephant will become exterminated before long. An international conference has been held upon this question and a set of measures have been framed and recommended for promulgation.

A Gasoline Tractor of 100 Horse-power Capacity

A Mechanical Horse for the Farm

By Frank C. Perkins

The accompanying illustration shows the construction of a novel gasoline or oil tractor designed at Racine, Wis., for use on the farm in plowing, hauling and threshing or for driving saw mills, shingle mills, pumping machinery or stone crushers. This gasoline tractor is equipped with a four-cylinder motor of the four-cycle type developing from 81 to 100 horse-power.

The piston speed is 750 feet per minute, and the four-cylinder engine develops 81 horse-power at 450 revolutions per minute, the cylinders having a diameter of 9 inches and a stroke of 10 inches. The fuel consumption averages one pint per horse-power per hour. The crank shafts have five bearings lined with babbit, the shafts being forged of solid steel. The connecting rods are of the same material and two and one-half times the length of the stroke.

The machine is self-oiling. All that is necessary is to occasionally replenish the reservoir with oil, a force pump does the rest. The oil reservoir or splash box is made of galvanized iron and is bolted to the motor main frame, being "oil tight." It can be easily removed, when the entire crank shaft is exposed to view and all parts inside the crank case can be freely inspected or adjusted.

The exhaust is carried by a manifold pipe directly to a very efficient muffler, which completely deadens all sound, without causing any back pressure. The water is circulated by a powerful rotary pump and is discharged through gratings into a fan where it is effectually cooled before entering the storage tank. This tank is placed on the forward part of the tractor, over the front wheels.

The frame is composed of I-beams, one on each side, with cross pieces extending between them, to which they are riveted. Braces are attached to the upper and lower cross pieces to prevent any twisting of the frame through the strains incident to the transmission of so much power through the shafting axles and boxes, which are carried by the I-beams.

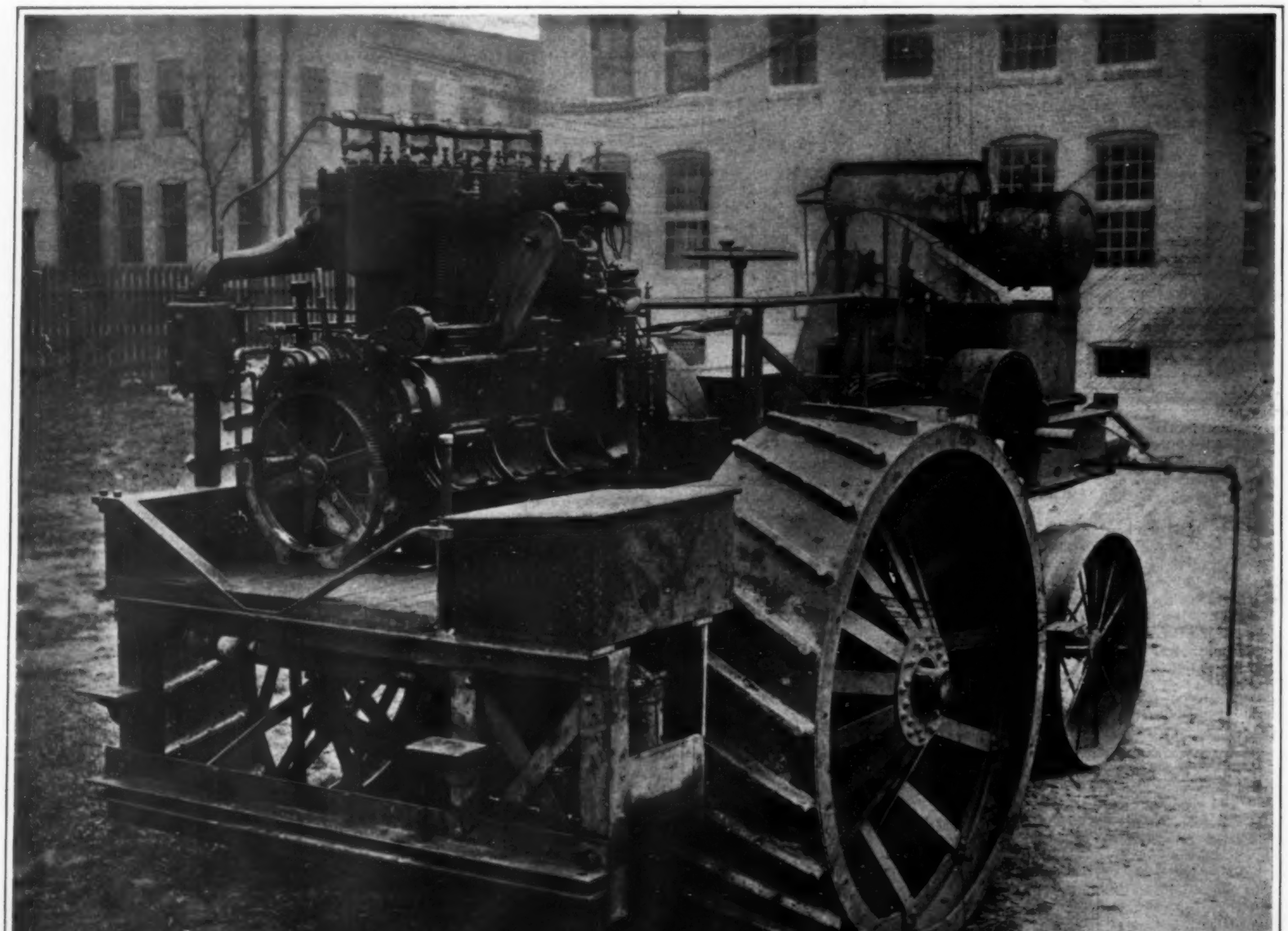
The design of the spring-mounting is quite an important feature in engines of considerable size. On this tractor helical springs are used two in each box. The cylinders engaging the springs are cast with steel flanges at their upper ends which are riveted to the under sides of the I-beams at the required position. The hollow pistons which contain the springs are turned up to fit into the cylinders so as to work freely inside them. The lower end of these cylinders are forked to fit the trunnions on the axle box proper, so as to allow free movement in every direction, and additional springs are provided to absorb shocks when traveling over rough roads. The front axle is mounted on springs of the same type, and has free movement in every required direction. This arrangement is neat, and works perfectly, causing the machine to ride very smoothly and preventing the jarring off of nuts and the working loose of parts, so common an occurrence in engines without springs.

The rear wheels are of steel, and have steel hubs. They are 6 feet in diameter by 24 inches wide. The spokes are riveted to the steel hubs and to the angle iron rings inside the rims by two ¾-inch rivets at each end—put in hot by machinery.

Extensions are provided to attach to the wheels for plowing on rice or cotton lands, at an extra cost, according to width. The front wheels are 43 inches in diameter by 14 inches wide, and are of ample strength, yet as light as it is thought safe to make them.

The steering wheel is situated near the center of the length of the tractor and near the right side, so that the steersman can see the road ahead of him, and is at the same time within easy reach of the controlling levers, the clutch lever, the reverse and the brake, also the carbureter, switch, magneto and governors on the motor.

Adjustable hitching bars are located at the rear end of the tractor, so arranged that any number of plows can be attached within the range of the power of the tractor or a single draw bar may be used for hauling wagons.

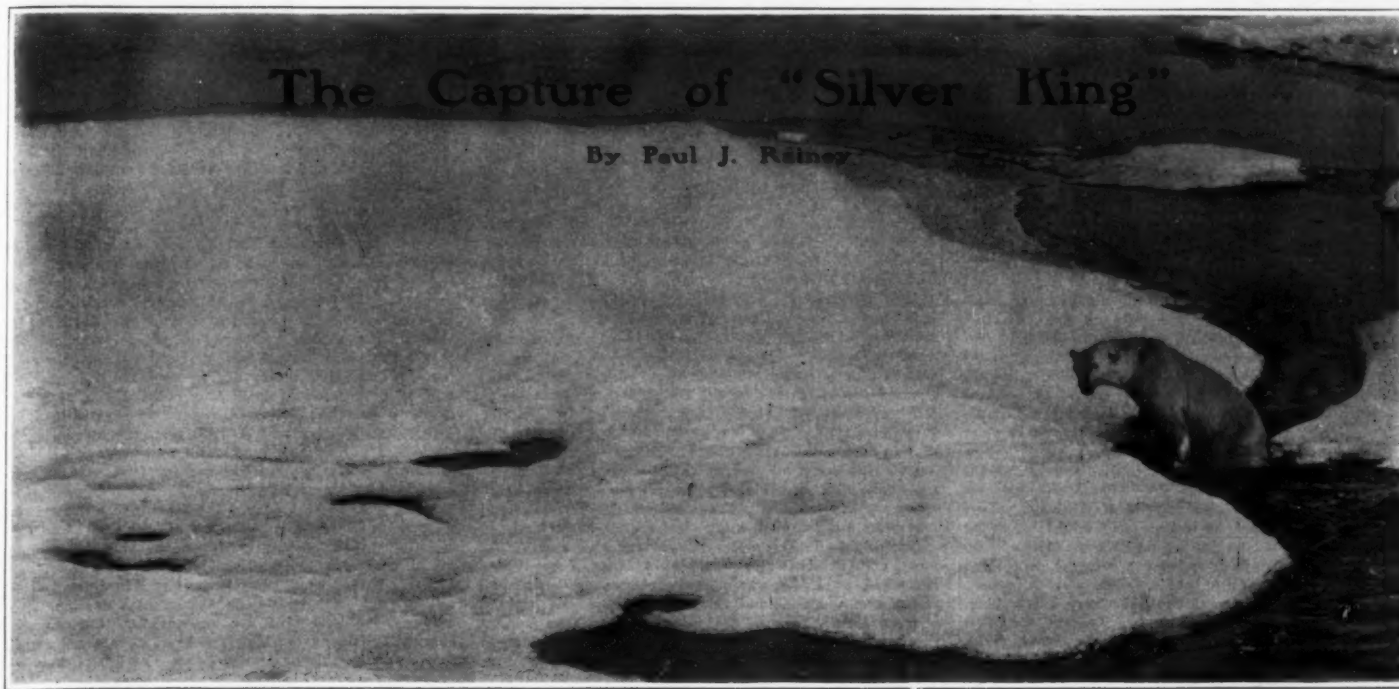


ONE HUNDRED HORSE-POWER GASOLINE TRACTOR, ESPECIALLY ADAPTED FOR FARM WORK

Experiments with a Quartz Mercury Arc

A mercury arc when properly formed, can be made to rotate very rapidly. This fact was brought out by Prof. Dufour, of Paris. He uses an inverted bulb partly filled with mercury, and a quartz tube is pushed up through the mercury until the end is somewhat uncovered, thus dividing the mercury into an inner and an outer zone, separated by the quartz. Connecting the current to the two zones and making a vacuum, an arc is formed across the end of the tube between the two portions of mercury. Such arc is found to rotate at a very high speed around the end of the tube, so that it appears to the eye as a ring of light. Experiments with a revolving mirror show that the arc rotates in fact and is not continuous. He calculates the speed to be from 8,000 to 15,000 revolutions per second. This latter number is obtained when the arc is placed in a strong vertical magnetic field, by mounting the whole apparatus between the poles of an electromagnet. Here the arc changes in character and gives a brilliant light. Considered from a practical standpoint, the expenditure of current in the electromagnet does not follow the increase of light, which is an advantage.

It is reported in the *Railway Gazette* that the government of Panama have contracted with the Panama Railway Company to build a line from the city of Panama to David, the capital of the province of Chiriqui. The distance is about 274 miles, and it is expected that the route surveyed by the Intercontinental Railway Commission in 1893 will be followed. The line will traverse a rich district, and will be an important factor in the development of a large and fertile section of the republic.



A GREAT POLAR BEAR STANDING ON EDGE OF ENORMOUS ICE PAN

SO MANY of my friends have asked me how the large polar bears were captured which I brought back from my recent hunting expedition in the arctic regions and presented to the New York Zoological Society, that I am tempted to gratify a desire that is perfectly natural.

On Saturday, July 30th, at three o'clock in the morning, in one of the small bays of Ellesmereland, about the seventy-seventh parallel, we sighted a large bear on the ice, a mile or two ahead. He stood on the very edge of an enormous pan of ice which extended some two miles back to the shore. The lofty mountains of the mainland, furrowed with enormous glaciers, made a beautiful background, and the cold midnight sun, together with the arctic calm, completed a picture that any man would remember to his dying day.

The bear stood with his long neck thrust well forward, trying to get our scent. Probably he never had seen man before. We headed almost straight for him, and when the ship hit the ice a hundred yards to his left, he took to the water like a duck.

One of the most remarkable things about a polar bear is his cleverness in diving from a pan-ice. The most difficult dive for an expert swimmer to make is from something almost at a level with the water. The bear makes a more beautiful dive than I have ever seen made by a human swimmer, and when he glides into the water, he leaves hardly a ripple behind him. They cannot stay under water very long, however, as we found when pursuing them with the launches.

We quickly decided to take that bear alive, and after cutting him off from the ice we lowered our launch and started in pursuit. Although these bears are able to stay in the water for hours, they are not very fast swimmers; and we very easily overtook our quarry. When we ran close up to him, he turned to fight; and then we threw a rope lasso over his head, took a turn on a cleat and started to tow him to the ship. His struggles were something terrific, and in a moment he had thrown the rope off his neck and was free. Recoiling our rope, we threw it and caught him again, and again he fought his way out of the noose to freedom. This was repeated many times. He rarely stayed in the rope for more than three or four minutes at a time, as the noose would slip over his small head very easily, when we would be compelled to go back and start all over again.

Finally, however, the rope held, and we succeeded in getting the bear to the ship, when our men swung out the large crane or derrick, operated by a powerful steam winch, to hoist him aboard. When we passed the rope to the hands on deck they were compelled to hold the animal very tightly to keep him from climbing into the launch. Presently it seemed to me that the bear was choking, and I ordered the rope loosened at once. Too late! His eyes were glassy, and he was stone dead.

This unfortunate experience taught me something, however, in the art of catching large bears, and I decided to use different tactics the next time. At the same time we discovered that the cages bought from an animal dealer in New York were too small, the dealer evidently thinking we intended to catch cubs, whereas, in reality, we were expecting to capture bears weighing from 900 to 1,100 pounds. The first mistake we made was in getting the rope squarely around the neck of the animal, so I decided that the next bear we roped I would leave the noose slack until we had gotten his forelegs through it, when we could hoist him on board and lower him into the hold without any danger of choking him.

On Thursday, August 4th, we sighted a large bear that the Eskimos took to be a female, but which proved to be the large male bear now in the Zoological Park, swimming among the small broken pans. We lowered the launch and started after him. We had considerable difficulty in getting close to him, as he would gain on us very rapidly whenever he crossed over a pan which we were compelled to go around. Finally, however, we succeeded in cutting him off by running between him and the pan for which he was making. Just then a very laughable thing happened. Capt. Bartlett, who was steering the launch, was sitting on one side, at the wheel. When the bear saw that he was cut off from the pan, he dove, and we thought he would come up at the other side of the boat. This, however, was not in his mind, and he came up directly alongside, and smashed the boat a terrible blow just about a foot under Capt. Bartlett. Bartlett gave one wild jump across the boat, not even taking time to change his sitting position, and landed very neatly on the seat of the other side.

The bear seemed to have an idea of getting into the launch, and we had to punch him away with the boat hook. Finally we succeeded in roping him, and this time I took good care to leave the rope slack until he had put his forelegs through it, when I took a turn with our end of the rope around a cleat just as the bear was busy climbing out on the ice. In the excitement, we had neglected to reverse the engine, and when he went out on the ice he very nearly took the launch with him. To have a 900 or 1,000-pound bear fastened to your launch and dragging you out on the ice, under a full head of steam, is not a very pleasant position to be in. At this time the bear could very easily have gotten into the launch!

Finally, however, we succeeded in slacking away the rope, got the engine going astern, and gradually started to drag the animal into the water. It was a wonderful sight to see this enormous brute with a strong rope just behind his fore shoulders. He would rear on his hind legs, bite at the rope and jump up and down; but the good old Standard motor in the launch did not go back on us, and we steadily and surely dragged him toward the edge. Finally, seeing that the inevitable was coming, with a vicious growl he plunged into the water and started for the launch.

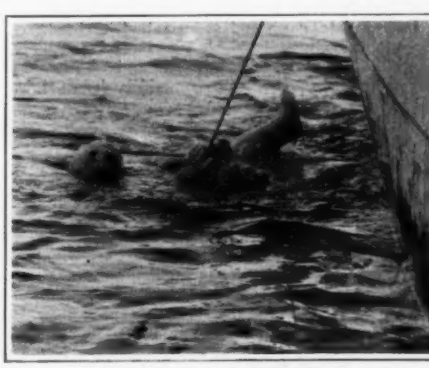
We did not have much difficulty in keeping him out, except when we were turning the launch around and getting it going ahead toward the ship, half a mile distant. The way he churned the water, and twisted and surged was really thrilling, but he had left the ice pans forever.

We signalled the ship to move into open water, as we needed plenty of sea room in which to handle our bear, having had all the experience we wanted in the broken ice.

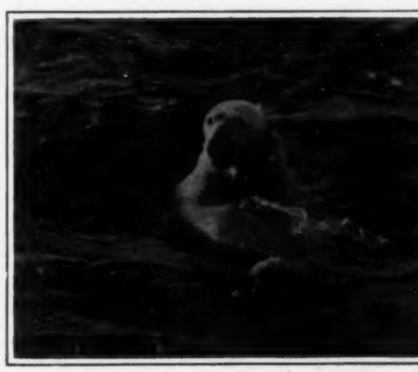
After we had gotten some 200 or 300 yards away from the pan-ice, the big brute succeeded in getting out of the rope, and I was compelled to rope him again. This time he would not keep his head high enough out of the water to enable me to get the rope over him, so we were compelled to run up close and hang the noose on the end of the boat hook. By dropping the noose over his head and carefully allowing it to stay slack until he had gotten one or both legs through, we at last succeeded in getting him fast once more, and started to the ship, but not, however, before he had made one or two unsuccessful attempts to climb into the launch. The placing of the noose over his head with the boat hook had its disadvantages, and was rather dangerous, because we were compelled to go very close to the bear.

We towed him to the ship, swung out the crane, fastened the hook onto the rope and, in the twinkling of an eye, Mr. Green, the mate, had hoisted him high into the air and swung him over the ship's deck. This caused a wild stampede among the Eskimos, who were perfectly familiar with the strength and power of a full-grown male polar bear. Willing hands were at the swinging tackle of the derrick, however, and in another moment we had the roaring, raging monster over the hatch of number one hold. As soon as he had been gently low-

STRUGGLE OF THE BEAR IN RESISTING TOWING



FINALLY THE ROPE HELD



THE BEAR REPEATEDLY THREW OFF THE LASSO

ered, all hands made a wild rush for the hatch to have a look at our pet.

We found him surprisingly cool, merely sitting on his haunches, growling, and making the champing noise peculiar to bears when angry. The rope was still around him, but no weight being on it the noose was quite loose, and as soon as he moved around it fell off.

The next day, to my surprise, our captive ate small pieces of bread and meat that were thrown down to him. Then the question arose, how shall we get him into the cage? We needed some of the coal under the bear to keep the ship trimmed. It was a very serious situation, as the firemen did not show any willingness to go down for the coal. At once we set to work to knock our small cages to pieces, and build a larger one, some ten feet long and six feet broad and high. We used the iron bars for the door, and the sheet iron for the bottom.

After starving our bear for four or five days, we pieces of bread and meat that were thrown down to him. fresh water inside the cage and lowered it down to the bear. He started directly in, but the sailor who was working the trap door let it drop too soon, and the bear held it up with his back while he backed out.

This episode seemed to make the bear very angry, for he jumped upon the top of the cage, and found that he could put his head and forepaws over the edge of the hatch and onto the deck!

Again there was a wild stampede of Eskimos, sailors and dogs, for it looked as if he surely would be up on the deck in an instant. In the excitement, Michael, the wheelman, left the wheel, and for a moment everything was in a state bordering on panic.

At this point one of the sailors did a very brave thing. He ran up and struck the bear heavily over the head with a deck mop, whereupon, after giving a savage growl, the animal went back into the hold. It was fortunate that he did so, for had he gone overboard in the heavy sea that was running it would have been impossible to have stopped and picked him up, and we would have been compelled to shoot him.

Immediately we hoisted the cage out, and waited another twenty-four hours, when it was again lowered with a good supply of walrus meat and fresh water, as before. This was quite enough for "Silver King" (as we named him) and in he went. Without taking time to untie the rope that held the trap-door, we cut it; the door fell into place, and our bear was in his cage. Again the steam winch was brought into play, and we soon had both cage and bear hoisted on deck.

As the crowd of Eskimos and sailors collected around in front of the cage, the bear made terrible lunges at them; and every time he lunged at the bars it was impossible for the Eskimos to stand still. They simply had to break and run.

Everything went well until we struck warm weather, and started washing him off with the deck hose every morning. Although he had quieted down, this morning ablution business did not suit him at all, and then it was that he made up his mind to get out. The construction of the cage was much too light, and on a dozen different occasions he very nearly succeeded in escaping. It was terrifying to see him grab hold of the smooth side of the cage with his teeth and tear out splinters a foot long. This we finally overcame by nailing a board over each hole, with large spikes through it; but "Silver King" was very clever about biting around those spikes, and never, to my knowledge, did he scratch himself.

One night during a terrible storm the cage broke loose, and, as the water was running free of the decks, it looked as if he was surely going overboard. The alarm was sounded, and the entire crew turned out to help secure the cage. After heaving the ship to and slowing her down a bit, they succeeded in getting on the well-deck, and making the cage fast. Another time, while we were at supper, a sailor put his head in at the door and with a respectful salute said, "Sir, the bear is out!" Someone said, very sensibly, "Please close the door!"

It seemed rather dangerous to go down on the well-deck, as it was a very dark night. However, we got some lanterns, and hurrying down to the cage we found that the bear really had his head and shoulders out. With the aid of a stout boat-hook, we succeeded, however, in driving him back in, and soon had the hole boarded up. After this we always kept a sailor watching the bear, day and night; and I believe we must have driven several thousand nails into the sides of that cage. After our arrival at City Island I always kept my big 401 Winchester handy in case of an emergency.

After Dr. Hornaday and his men unloaded the bear at City Island, an amusing incident happened. The police captain of the precinct through which they were going to take the bear, got very much worried for fear he would get out, especially after I explained to him that the 32 calibre revolvers his officers were carrying would only serve to get him well stirred up. He asked me if I would loan him a real gun, which I was very willing to do; and after he had called in one of his officers, I gave him a long discourse on how to load and fire a 401 Winchester. A half-hour afterwards, seeing the officer parading up and down the dock with the 401, much to the admiration of several hundred men and boys, I decided to see if he still remembered his instructions. I said to him: "Supposing the bear got out, and you wanted to shoot him, how would you go about it?" Pointing to the safety catch on the side, he said: "I would push the jigger over, and pull the trigger." As I had purposely not placed any cartridges in the barrel, he could not have done any great execution.

I ask indulgence of my readers for this somewhat lengthy article on catching my bear. I am not an author, and probably never will be one, so I hope they will look upon my article with the greatest indulgence.—Reprinted from the New York Zoölogical Society's Bulletin.

The Physics of the Polar Seas

Scientific Aspects of the World's Icy Regions

Almost all our knowledge of the physics of the Arctic Ocean is derived from the observations made by Nansen during the drift of the "Fram," although something has been contributed by the more recent explorations of Amundsen (1901) and the Duc d'Orléans (1905).

The Arctic basin is the northernmost of the deep depressions which lie north of the Atlantic and are separated from it and each other by submerged mountain chains. The first of these ridges extends from Scotland, through the Faroe islands and Iceland, to Greenland. Its crest is nowhere more than 2,000 feet below the surface. The most northerly ridge, stretching from Greenland to Spitzbergen, has not been completely explored, but it is not believed to be more than 2,600 feet below the surface at any point. As the sea between Spitzbergen and Norway and Bering Strait is shallow, the polar basin has no deep connection with the great oceanic basins. It forms what is called a Mediterranean basin, *i. e.*, an isolated deep sea, in which the temperature and salinity, from surface to bottom, differ from those of the open ocean at corresponding depths. The deep Arctic basin extends from the Greenland-Spitzbergen ridge to and beyond the islands of New Siberia, but its eastern limit is not exactly known. The shallow sea which covers the submerged part of Siberia is from 310 to 370 miles wide and is rarely more than 330 feet deep. New Siberia, Franz Josef's Land and other islands rise from this submerged continental slope, north of which the sea bottom descends rapidly to the great depths of 10,000 to 12,500 feet recorded by Nansen.

At the bottom of the Arctic basin the water is warmer and saltier than that of the adjacent seas of Greenland and Norway. The waters of the basin are divided into three strata: A cold and not very salt stratum about 650 feet deep; a warm, salt stratum extending from the depth of 650 feet to that of 2,600 feet, and a cold, salt stratum extending from the depth of 2,600 feet to the bottom.

This phenomenon is due to a discontinuity in density between the superficial layer, which is diluted with river water, and the bottom layer, so that the warmer water of intermediate density flows in between them from the south. Nansen's observations, all of which were made at the same place and within a short time, show minimum temperatures at depths between 160 and 200 feet, and maxima between 1,000 and 1,300 feet, below which point the temperature decreases slowly to a second minimum near the bottom. The proportion of salt increases rapidly from the surface to a depth of between 650 and 820 feet, where it is about 3.51 per cent, and thence remains nearly constant to the bottom.

In the superficial cold stratum the temperature varies from 32 deg. to 28.8 deg. F., while the salinity increases from 3 per cent near the surface to 3.47 per cent at the depth of 650 feet. This stratum is composed of fresh water, derived chiefly from Siberian rivers, mixed with sea water coming from the south. The precipitation in the Arctic itself is comparatively insignificant. Hence the polar sea presents very favorable conditions for the formation of ice, which increases the salinity and density of the water immediately beneath the ice, and this sets up a rather active vertical circulation within the limits of the cold superficial stratum, especially near the coast. The hummocks formed by ice drifting together often rise 20 feet above the water surface, which corresponds to a submerged depth of 160 feet, unless they are broader below than above. Some solitary blocks are certainly deeper than this. The water in contact with the ice is cooled to the freezing point corresponding to its salinity. These conditions indicate a minimum temperature of 28.6 deg. F. at a depth of 200 feet, which is approximately the case. The calculated and observed temperatures agree exactly, however, only to a depth of about 66 feet. As the depth increases beyond 200 feet the temperature rapidly increases to 32 deg. F. at a depth of 590 to 660 feet. The isothermal surface of 32 deg. F. is the boundary between the superficial cold stratum and the intermediate warm stratum.

Annual variations in temperature and salinity are caused by freezing and thawing. In open channels between the ice floes in summer Nansen observed a stratum, sometimes 10 feet deep, of nearly fresh water having a temperature of 32 deg. F. or higher, distinctly separated from the colder and saltier water beneath. Often this surface of separation was marked by fringes and long horizontal needles of ice or even by a continuous sheet of ice in narrow channels. This layer of fresh water disappears in autumn.

As the ice drifts across the polar basin it increases in thickness each year, because much more ice is formed in winter than is melted in summer. As the "Fram" drifted westward, the salinity of the surface water increased and its temperature (equal to the freezing point corresponding to the salinity) diminished.

The superficial cold stratum is deepest toward the east, as it is derived chiefly from Siberian rivers. Nansen found its depth 660 feet, north of New Siberia, but only 560 feet in its eastern part.

The intermediate warm and salt stratum is characterized by a temperature above 32 deg. F. and a salinity exceeding 3.47 per cent. It is evidently derived from the deeper portions of the Gulf Stream, which, deflected by the subaqueous plateau between Spitzbergen and Norway, skirt this plateau and the east coast of Spitzbergen, near which they rise over the Greenland-Spitzbergen ridge, and flow into the Arctic basin. Here they are turned to the east by the earth's rotation and flow along the edge of the submerged base of Siberia.

As the Gulf Stream water is confined between two cold strata it becomes colder as it advances eastward. It shows a maximum temperature of 33.8 deg. F. at a depth of 1,050 feet, and a maximum of 32.6 deg. F. at a depth of 1,475 feet, north of New Siberia. At the same time, the thickness of the stratum warmer than 32 deg. F. gradually diminishes. The lower isothermal surface of 32 deg. F. is found at depths of 2,950 feet at Spitzbergen and 2,625 feet near New Siberia.

The cold stratum below shows a uniform salinity of 3.51 per cent, while its temperature diminishes from the lower isothermal of 32 deg. F. to a minimum of 30.6 deg. F. near the bottom. A small increase below this point is due, in Nansen's opinion, to the internal heat of the earth. At a depth greater than 3,300 feet the temperature increases eastwardly, in which direction the temperature of the intermediate warm stratum diminishes. Hence Nansen conjectured that these two strata were composed of the same Gulf Stream water which had become cooled during a descending spiral course round the pole. But as this water is protected from radiation by the Arctic water above, and contact with the latter cannot cool it to the observed bottom temperature. Amundsen's observations in Barents Sea suggest a better explanation. The superficial waters of the Gulf Stream enter this sea, where, by cooling and forming ice in winter along its shores, they yield the cold and very salt bottom water of the central depression. There is no deep channel by which this cold water can enter the Arctic basin, but the same action probably takes place north of Nova Zembla and Franz Josef's Land, whence the cold water can flow into the polar basin.

This description of the three strata of the Arctic ocean is condensed from an article in *La Nature* by Th. Hesselberg, who gives the information summarized below.

The distribution of density can be deduced from the observed distribution of temperature and salinity. In the Eastern Hemisphere the surfaces of uniform density slope downward toward the east, most steeply near the surface, but very distinctly throughout the upper cold stratum, producing an eastward current at the bottom of this stratum and a westward current at the surface. In general, the forces due to differences of density conspire with the action of the prevailing winds on the rough ice to produce a current flowing over and on both sides of the pole from Bering Strait to the passage between Greenland and Europe, through which the waters of both the Siberian and the Canadian rivers escape from the Arctic basin. The ice closely follows these lines and consequently appears to drift eastwardly in the Western, and westwardly in the Eastern Hemisphere, but the water immediately beneath the ice, more strongly influenced by the earth's rotation, exhibits a tendency toward a circulation from west to east around the pole.

The drift of the ice across the polar basin usually occupies three or four years. Hence the appearance of the ice varies greatly with the locality. It is thin and smooth near the Siberian coast, but becomes thick and rough as it approaches Greenland. The ice is continually subjected to lateral pressure, due to winds and currents, which produces undulations and ridges. It is very much distorted along the north coast of Greenland, against which it is forced by the current. The expansion of ice in cooling produces enormous pressure in severe winters, and piles the ice into great hummocks. These, however, are small in comparison with the icebergs, detached from the land ice of Greenland, which drift southward with the polar current. Some icebergs rise more than 300 feet above the water surface, and probably extend to depths of 1,300 to 1,600 feet. They are less compact than sea ice, as they consist entirely of compressed snow. Icebergs have been encountered in latitudes less than 40 degrees near the American coast, but they are rarely seen south of the Faroe Islands off the east of Norway.

Although the Antarctic region, occupied by a large continent surrounded by water, presents conditions precisely opposite to those of the Arctic basin, the two polar seas have some phenomena in common. The Antarctic is still very imperfectly known.

The melting of the great masses of ice detached from the Antarctic continent produces a superficial cold stratum of small salinity in the southern parts of the great oceans. The "Gauss" encountered, at 65.5 deg. S. lat., a stratum 2,460 feet deep, having temperatures below 32 deg. F. and salinities increasing from 3.30 per cent at the surface to 3.46 per cent at its base. A minimum temperature of 28.6 deg. F. was observed at

a depth of 590 feet. This is three times the depth of the Arctic minimum. The difference is due to the vast mass of the Antarctic icebergs in comparison with the Arctic hummocks.

Below this cold stratum to a depth of about 6,500 feet, extends a stratum of water warmer than 32 deg. F., having a uniform salinity of 3.46 per cent. The same salinity is found at still greater depths, but the temperature gradually diminishes to 31.3 deg. F.

We find here, then, a warm stratum between two cold strata, as in the Arctic. The upper cold stratum is evidently moving northward, while the warmer but denser intermediate stratum consists of water flowing southward from warmer regions. The force deduced from the distribution of salinity and density at the surface is directed northward, but the prevailing winds, aided by the effect of the earth's rotation, deflect the surface current toward the west. This current is finally merged in the eastward current which marks the limit of the Antarctic circulation, at about 50 deg. S. lat. The density of the surface water diminishes in going either northward or southward from this line.

The Antarctic ice is partly marine and partly terrestrial. Some of the colossal icebergs are composed chiefly of blue ice formed along the shore. Antarctic icebergs are seldom encountered north of latitude 45, but in 1894 the remnants of one were seen in 26½ deg. S. lat.

Our knowledge of the polar seas will almost certainly be improved in a few years. A ship drifting with the ice is in the best possible condition for observing the physics of the sea. The expedition headed by Roald Amundsen will start from Bering Strait in the autumn of 1911, equipped with the most improved oceanographic apparatus. The plan is to cross the Arctic basin as near the pole as possible. Antarctic expeditions are also projected.

Characteristic Features of Rocky Deserts

Relation of Protective Crust to Ravine Formation

By Dr. H. Burmester

IN every rocky desert are found two distinctive features which form characteristic phenomena of the wide, barren landscape beaten upon by the fierce sun of the sub-tropics: the so-called tropic protective crust and the intricately winding dry valleys with smooth, steep sides known as wadis.

These phenomena have hitherto been regarded as separate and dissociated in cause, but recent investigations have clearly demonstrated their close connection and interdependence.

The term "tropic protective crust" is used to designate the thin hard coating found upon all desert rocks. This coating, due to the intense dry heat, consists of a layer of iron and manganese oxide. It may be distinguished from the rock itself by scratching with a sharp instrument.

According to the investigations of Mr. J. Walther, a yellow color shows a newly formed crust containing a hydrated iron oxide, a red color shows an older crust which has been changed into iron oxide by loss of water, and a gray tint shows the presence of manganese oxide.

The colors of the crust vary between deep black, clear gray, and all shades of brown, which generally shows the presence of silicic acid, the darker the stone the richer being the crust in this acid.

The second marked phenomenon of these deserts are the ravines cut deep in the horizontal plateaus, inclosed by lofty, unscalable walls, and often ending in a steep blind wall after long extents, measured by journeys of hours or even days.

The desert east of the Nile valley, beginning near Cairo, is a characteristic rocky desert and affords an admirable as well as accessible field of observation.

I. INVESTIGATION OF EFFECT OF PROTECTIVE CRUST ON INTENSITY OF EROSION.

In the desert a distinct difference is to be noted between stone exposed to direct sun and that which receives little or no sunshine.

The first is covered with a crust which is harder than the mother stone, and is severely eroded on the surface, to which fact is due the name tropic protective crust.

This crust or rind is formed wherever direct sun rays fall, but also creeps into tiny superficial cracks into which no rays penetrate. It would thus seem to be due to the heating of the stone, which favors a chemical combination of the stone with the iron and manganese salts of the atmosphere.

Those portions of the stone lying in shadow, on the other hand, are not protected by a crust against superficial erosion. Hence the moisture of the night dew or an occasional rain remains longer and chemical erosion proceeds unhindered.

Erosion therefore begins in the shadowed part forming tiny cracks or projections which gradually increase inward until a cavity is formed in the side or top, or the projecting portion, eaten away from beneath, falls of its own weight.

This is called erosion from within outwards. When a large piece of rock forming such a projection breaks off, a protective crust is at once formed on the exposed surface of the breach. The fallen block lying on the ground shows the protective crust on every side, but betrays inner cavities which have eroded outward so as to break through the crust, in which case the crust extends in patches from the roof of the cavity.

The pendent parts shadow the bottom of the cavities formed by them and therefore accelerate the erosion. But these fragments and projections owe their existence to the protective crust since this preserves them from too rapid decay.

Often, indeed, the mother stone is entirely eroded, and only the harder crust still hangs to the rock as the roof or sidewall of a cavity.

Thus we see that the term "protective" crust is accurate only in that the stone immediately underlying it is protected. On the contrary, the crust favors the shade erosion which is the dominating factor in the desert, since through its greater hardness and durability it allows such shadow-making portions of the rock as the roofs or walls of caves to stand longer than they otherwise would.

Since the crust favors the dominant cause concerned in the characteristic rock forms of the desert, by logical deduction it must be a significant factor in the formation of the wadis.

It is not, however, here implied that the crust is a necessary feature of erosion, since crusted and non-eroded rocks are found.

In order to discover whether there was a "weather side" in the desert, I examined Egyptian architecture.

In the desert itself there are too many factors concerned for a definite result to be reached. The direction of the wind and the hardness of the stone are determining factors, and moreover it is difficult to find a block of an undoubtedly synchronous breach and yet of a different orientation.

But it is a well-known fact that the stones employed in Egyptian buildings show crusts after 6,000 years.

One of the best known examples of this is the dam discovered by Schweinfurth in the Wadi Geraui at Heluan. The blocks used there, which have an eastern exposure, are only slightly attacked on top and show a marked browness; yet a distinct cavity is eroded in the soft gypsum of every stone.

For our purpose, however, the pyramids offer the best example, being exposed to every point of the compass. Of the pyramids at Ghiseh only the Chefren still shows a portion of the original covering near the summit. The others show only eroded blocks, the time of whose exposure is undiscoverable.

All four sides of the Chepen pyramid have an equally brown tint, showing an equal amount of erosion. The vertical summer sun, therefore, has strength enough to develop the crust even on the north side.

This facilitates the study of the wadis, since in investigating the crust erosion the orientation of the rocks may be disregarded without its becoming a serious source of error.

If we look at the Sphinx we observe that on the back of the head there is a strongly marked crust and obvious erosion has begun, while on the eastward-looking face there is little crust and little erosion. It seems to remain true that where there is little crust there is little erosion.

A special form of the crust is here referred to, in which on normal brown-crusted rock a slag-like applied crust appears in spots. This is black and always raised in relief. If such a stone is cut in sections there is usually found lying under these accretions darker stone containing lumps and hollows, or else arranged in layers. The hardness tests show it to consist of hornstone injections in chalk, which explains the dark color, since this gains in darkness as it gains in silicic acid. It is not unusual for hornstone to be found in localities where fossilized wood is often found. In any case we see that harder stone raised in relief lies opposite crust-covered chalk.

When the chalk weathers its protective crust does not completely resist the outer erosion, but renews itself constantly much like the human skin without showing definite flaking.

In this process of renewal it takes material from the mother stone and occasions therefore a steady erosion from without inward.

This erosion, which is naturally very slow, proceeds side by side with the much more rapid and important shadow erosion.

The crust does not always work continuously into the rock. There are cases in which the crust breaks loose from the rock in layers—the process of desquamation. In such instances the action is ascribed to solutions of salt which have filtered in and then crystallized. . . .

WADIS.

The extensive course of all wadis suggests water as the creative agent. The question is whether the quantity of water now available is sufficient to have caused them or whether a greater precipitation formerly existed.

For the Sinai desert a pluvial period seems indicated. Hume concludes from marked boulder and pebble deposits that great snow fields existed in former ages. He considers it certain for Sinai that now in the pebble deposits of the wadi mouths the denudation exceeds the deposit, and that therefore smaller streams now dig their beds in the pebble deposits washed down by former mighty floods.

Direct conclusions as to the Nile valley cannot be drawn from this, but close observation of wadi formation gives various indications that water erosion has had a share in modeling the relief of the desert, and that to a greater extent formerly than now.

Take the Wadi Hof, for example. It is at once obvious that we find ourselves in a valley where water has been active. The ground consists of rounded grains of sand. If there are contiguous walls we find definite water erosion grooves, with clearly defined wave marks. Here we find white eroded channels. Yonder we find heaped-up piles of rubbish.

Now let us direct our gaze to a bank of hard chalk over which erosive masses of water have undoubtedly plowed when some rare rainfall has sent down its revivifying floods. On this bank we find at spots where the water must flow with slight force light traces of crust, while wherever the water has dry furrows with violent deluges not the slightest remnant of the brown crust remains.

Thus we see that in many places the water has gained the victory, in others the crust has won the day.

In order to study better this conflict between crust and water I investigated the chalk banks in the branch wadis leading off from the main wadi, since there in all probability the crust action would be greater because of the smaller quantities of water.

This conjecture was verified, for without exception the ground of the branch wadis showed, wherever hard chalk banks were present, dark crust above earlier erosion marks.

In the foregoing I have sought to present a series of erosion phenomena which give an impression that the condition of the desert valleys of the localities considered cannot have been caused by such quantities of water as exist at present.

The conflict between the water and the crust gave us the clue, and showed how in the branch wadis the crust formation had the upper hand, while only in the main ravines could sufficient amounts of water collect to effectually oppose the crust formation.

This struggle was active when mighty floods still rushed through the valleys; but slowly the waters diminished and the crust won the upper hand.

The eroded chalk banks show positively that to-day the crust action is greater in extent than water erosion, for the bed worn by the rain water occupies only a small part of the whole width of the wadi. Moreover, those parts of the broken stone coated with the brown crust are not partially washed away again as we saw them in the main wadis.

If we observe upon a flat surface the formation of a wadi, we are struck by the long crooked strips of vegetation which lead to small depressions and mark the course of the wadi. It is in these channels that the water runs when it rains, forming pools and occasioning the growth of vegetation.

The roots of these plants preserve the moisture longer, and therefore give rise to more rapid erosion in their neighborhood than in dry localities, and thus assist the destructive action of chemical agencies later. At some point a projection is formed, cavities begin to be enlarged, and we have the commencement of a wadi.

The essential thing is, in my opinion, the co-operative action of vegetation and water, which loosens or disintegrates long strips of the desert and makes them more susceptible to subterranean erosion later.

That water is present in the sub-soil of the wadis is proved by the cisterns which are always found in the course of the valleys. But their excavation is continued at the present day essentially by crust erosion and the formation of projections.

But the apparent conclusion that no valleys of long extent can now be formed without kettle-shaped cavities is not justified. Let us examine more closely the erosion in the wadis. We know that huge blocks fall through being hollowed out and help to widen the wadi, their fragments forming the rubbish of the sloping sides. On the one hand cavities will be formed, on the other the valley will be cut back. But since in the backward lengthening process of the wadi the stone is prepared for subsequent weathering by the influence of vegetation and subterranean erosion the progress of the wadi in this direction will be considerably more rapid.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from *Globus*.

Excavations in the Ruins of Abasside Palace

ARCHÆOLOGICAL work of some interest was carried out by an expedition sent to Turkey from France and headed by M. Henry Viollet. He made excavations with the permission of the Turkish government in the ruins of the celebrated Abasside palace at Simara dating from the first half of the ninth century of our era. It is a unique specimen of the architecture of this period which is still very obscure. The present palace was the residence of the Arab caliphs who had been expelled from Bagdad for a certain period on acount of military seditions. The archæologist has now returned to Paris and made a report to the Academy on the subject.

Safety Stops for Steam Engines*

Practical Suggestions for Engineers

By W. H. Wakeman

A safety stop on a steam engine is of as much importance as a safety valve on a steam boiler. In this article most of the safety devices used in connection with the engine governor are illustrated and their action described.

A safety stop for a steam engine is any kind of a device that will stop an engine, should the governing

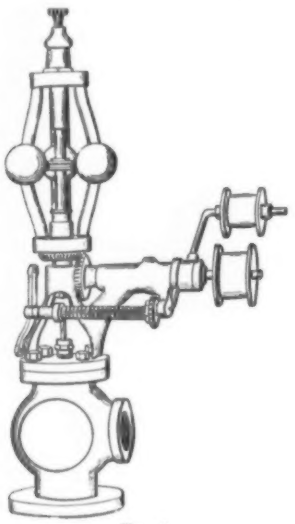


Fig. 1

apparatus get out of order, and, although some types of stop device will shut down an engine when the load is greater than it can carry under existing conditions, they should also be classed with the safety stop.

Fig. 1 shows a simple type of safety stop. An idler travels on the top side of the belt, and, should the belt break or slip off, the idler will fall into a lower position. This disengages the speed pawl, releasing the valve, which drops, shutting off steam from the engine cylinder. The packing in the stuffing box around the valve stem should be kept in good order, as it is possible to prevent prompt action of this stop should the stuffing-box nut be screwed down too hard on unsuitable packing, or on packing that has outlived its usefulness.

The governor shown in Fig. 2 is located on the engine frame about 4 feet from the cylinder, instead of directly over the steam chest. Should the governor belt break, or be thrown from the pulley, steam would be shut off from the cylinder. The device for opening the steam valves is similar to the Corliss gear. Steam is admitted and cut off automatically from zero to about one-half stroke, under normal conditions, and if more load is added the flyballs take a lower position and steam follows the piston the entire stroke, providing the balls and the center weight do not fall to their lowest possible position.

If the governor belt should break, or from any other cause the flyballs should move slower than usual, or stop, the center weight will drop as low as possible, which will cause the tripping toes on the cutoff mechanism to prevent the steam valves from opening, hence steam is not admitted to the cylinder, and the engine will stop. When it is time to shut down, a block is inserted, as shown at *A*. While this allows the center weight to go low enough to give steam to the cylinder during full stop and the center weight will fall to its lowest position. If it is desired to shut the engine down in regular service, close the throttle valve and as the speed slackens, the stop lever *B* is pushed inward against the spiral spring until it strikes the spindle, and is held there until the weight and collar *C* rests upon it. When the engine is started and the flyballs gain sufficient speed to raise the center weight, *B* is liberated, the spring throws it outward and the stop is set automatically.

A homemade device for blocking a governor on a Corliss engine is shown in Fig. 4. The sliding sleeve *A* is in a position for an average load on the engine, but if the throttle valve is closed the projecting pin *B* falls until

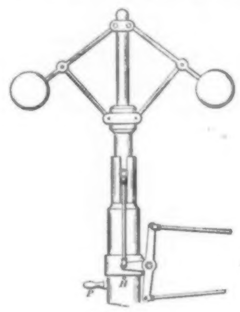


Fig. 6

it rests on the thick washer *C*, carried by the stationary pin *D*. This allows steam to follow the piston full stroke, and enables the engineer to stop the engine in any desired position. When the engine is started again and brought up to regular speed, *B* rises from the washer *C*, which is then removed from the pin *D*. This permits the collar *B* to drop low enough to prevent the steam valves from hooking on the catch blocks should the governor belt break.

An automatic device for releasing a governor after it has been blocked is shown in Fig. 5. As soon as the flyballs revolve fast enough to raise the center weight, the catch piece *A* turns one-half revolution to the right on

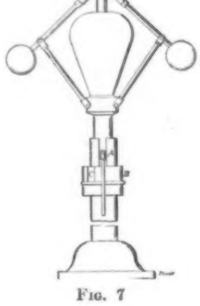


Fig. 7

the pin *B*. This automatically sets the safety stop ready for an emergency, because *A* will not stay in the position shown unless it is held there

Fig. 6 shows a safety stop in running position. When the governor is to be blocked while shutting down and starting again, the pin *P* is inserted in the hole *H* and prevents the flyballs from falling to their lowest position.

collar *B*, causing steam to follow the piston full stroke. If the collar *B* were moved until the vertical slot *C* is directly under pin *A*, and more load is put on the engine, the center weight will fall to its lowest position, causing steam to be shut off from the cylinder.

A governor fitted with a center weight appears to be much more sensitive than if the center weight were omitted, hence it ought to operate a stop motion almost instantly. This form of governor is more sensitive while in full operation than the style shown in Fig. 6, but the former is always operated at a much higher speed, and it will run longer after the belt is removed. The effect of this action on the flyballs is partially offset by the center weight. In either case great care should be taken to have the dashpot, which usually forms a part of such governors, properly adjusted, as otherwise it may hold the flyballs up for a few seconds, when time is very valuable, and thus cause much damage.

This warning may be needed in cases in which such need is least suspected, for the following reason. An engine may nearly always carry a light load, causing the flyballs to move on a high plane, and allowing the center weight to travel through a limited vertical space. Long service under these conditions results in a very easy movement of these parts through their ordinary limits, but when moving below these limits they may not move so easily. This difference would only be noticed when the engine is started, and not then unless the engineer is especially careful to observe the details

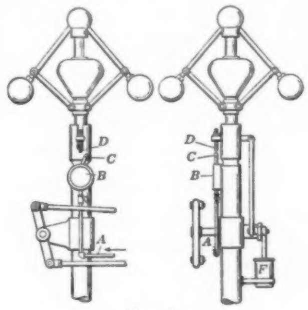


Fig. 8

of operation, for the only difference is that the flyballs must be given a higher speed than if there were less friction. Even this may not exceed the highest speed attained under common conditions. After steam is shut off by closing the throttle valve, and the center weight is moving downward, it may show irregular motion, but as this cannot affect any other part, it may not attract attention.

Fig. 8 shows two views of a governor equipped with a stop that is automatic in both directions. It is shown in running position. Steam from the bonnet of the throttle valve is carried through the small pipe *A* into the disk *B*, where it operates on a device similar to the Bourdon spring in a steam gage, which throws *C* out of a vertical position, as shown. Therefore, the bolt *D* cannot rest upon it, if the center weight is falling to its lowest position should the governor belt break or come off the pulley. Consequently the stop operates and steam is shut off from the cylinder.

When steam is shut off by closing the throttle valve, pressure falls in the pipe *A*, which is piped to the steam chest or to the throttle valve under the disk; hence, the spring inside of *B* carries *C* into an upright position just in time for *D* to rest upon it. When the throttle

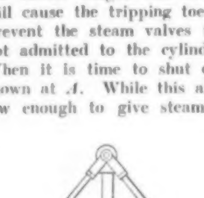


Fig. 2

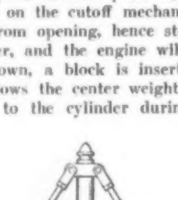


Fig. 3

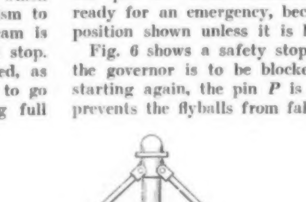


Fig. 4

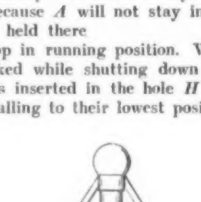


Fig. 5

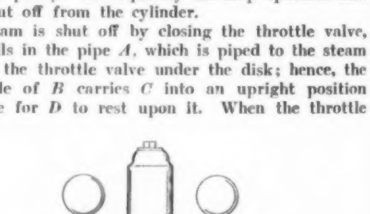


Fig. 9

stroke of the piston, it does not allow the safety stop to operate. This makes it possible to handle the engine properly, and not allow it to stop on either center. When starting the engine, and the throttle valve is wide open, the block *A* is removed from the governor.

Another device for blocking a governor is shown in Fig. 3, which, to a certain extent, is automatic in operation. It is shown in running position. The sliding block *B* is held in an out position by a concealed spiral spring. Should the governor belt fail, the flyballs will

* Reprinted from *Power and the Engineer*.

In case the engine should stop with the pin out of the hole *H*, first close the throttle valve, then lift up the flyballs and put the pin in the hole *H*. Then unhook the reach rod and rock the wristplate to its extreme travel in both directions so that both steam valves will catch into the catch blocks, and drop the reach-rod hook into place. Steam can then be turned on and the engine started.

The governor shown in Fig. 7 is in its running position with a heavy load on the engine. If more load is added the projecting pin *A* will rest on the movable

valve is opened again pressure begins to rise in the pipe *A*, but it is not sufficient to throw the lever *C* over until *D* is lifted from it by the action of the flyballs, thus requiring no attention from the engineer. *F* is a dashpot which prevents the center weight from moving too rapidly.

The small pipe *A* carries pressure to *B* when the throttle valve is open, but when closed, pressure is shut off from the stop.

A peculiar governor is illustrated in Fig. 9. Centrifugal force, caused by high speed, throws the governor

balls outward, and the bell cranks, to which they are fastened, raise the sliding sleeve which operates the long bell crank pivoted at the left-hand side of the governor. This gives motion to the horizontal rod *A*, and as it is connected to the tripping devices on the valve gear, it gives a long or a short point of cutoff according to the load carried. The cam *C* is shown in mid-position. When the engine is about to be shut down the long arm *C* of this cam is raised to a horizontal position by hand, hence the short arm *B* stands vertically and receives the projecting part of the governor. When the engine is started again the centrifugal force throws the flyballs outward, and the cam, being liberated, drops to the position shown by the dotted lines.

Every engine stop ought to be given a practical test at frequent intervals (say once each week), to prove that it is in working order. For illustration, take a Corliss engine with a flyball governor. Close the throttle valve until there is just enough steam admitted to maintain full speed. Suddenly force the flyballs down to their lowest position and keep them there for a few seconds by holding a convenient part of the governor. The engine will run faster for two or three revolutions,

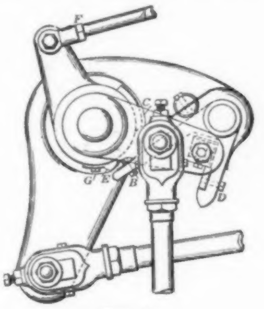


FIG. 10

and then gradually stop, provided the adjustments are properly made. If not, steam may be shut off from one end of the cylinder, and admitted to the other, but this will not give excessive speed. If it is not shut off at both ends, make an adjustment that will give the desired result, but do not change the comparative point of cutoff, for if they are even they should not be changed, and if the condition of the valve gear in this respect is not known, an intelligent change cannot be made. It is usually possible to set the stop motion without changing the point of cutoff, but on the other hand, there are ways whereby both can be changed together, and it is plain that these ought to be avoided.

Fig. 10 illustrates this point, and shows the gear for opening and closing a Corliss steam valve. The reach rod *A* is adjusted so that when *B* is carried upward by the lifting arm, it will strike the knock-off cam *C* and the latch *D* will be unhooked and the dashpot will close the valve. If the flyballs of the governor of this engine should fall to a lower plane than at present, the reach rod *A* would be carried to the left, and the safety cam *E* would move toward the right hand, striking *B* and preventing *D* from hooking on. Consequently the valve would not open and no steam could pass into the cylinder. It is possible for the valve gear to wear until *E*

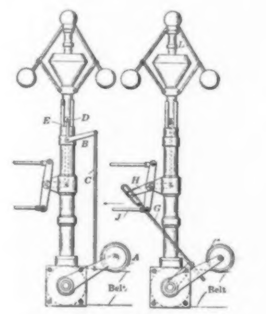


FIG. 11 FIG. 12

is no longer in proper position to prevent the valve from opening. A careless or thoughtless engineer will loosen the jam nut *F* and lengthen the reach rod until *E* will perform the duty for which it was designed. This action causes *C* to be moved from its proper position until it no longer disengages *D* at the right moment, resulting in an uneven cutoff for the engine, assuming that it was even before. The correct way is to let *F* remain as it is, and loosen nut *G* and slide *E* into proper adjustment and then screw *G* tightly down upon it.

An automatic stop which needs no attention from the engineer when starting or stopping his engine is shown in Fig. 11. The pulley *A* rides on the governor belt. The bell-crank lever *B* is kept in the position shown, by means of the long vertical rod *C*, as long as the governor belt remains in place. The flyballs and center weight are in position to give the longest point of cutoff to the steam valves, as the projecting pin *D* rests upon *E*. When the load is reduced, *D* rises, but *E* remains in position. If the governor belt breaks, *A* falls, *B* is also lowered and *E* is carried toward the right, therefore D goes lower than shown, and steam is shut off because the steam valves do not hook on and the engine stops. An important feature of this device is that if an overload is put upon the engine it will not be shut down. On the other hand, if the governor ceases to revolve for lack of lubrication or any other cause, and the belt remains on the pulleys, steam will be admitted full stroke to the cylinder, causing excessive increase of speed.

Another stop is shown in Fig. 12. The governor is

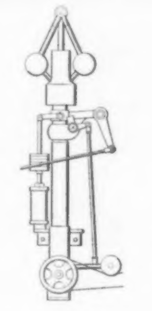


FIG. 13

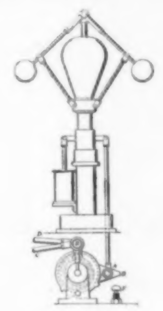


FIG. 14

shown with a medium load on the engine. The pulley *F* rides on the belt and during ordinary service this pulley does not change its position, consequently the slotted rod *G* is practically stationary. If more load is added the center weight is lowered, also the right-hand end of the lever *H*, the opposite end of which moves upward in the slot. The lower reach rod *J* moves as indicated by the arrow. If the load becomes lighter the centerweight rises and the upper reach rod is carried toward the left, shortening the cutoff. The same action takes place when the governor belt breaks, because *F* falls, and the slotted rod *G* is drawn down until the end strikes the pin in the bent lever *H*, the effect of which is to force the center weight upward, shortening the point of cutoff until it is reduced to zero and the engine stops. The collar *L* must be set high enough to allow the center weight to rise as described, but no higher. As the flyballs rise to operate the stop motion, the pulley F and its connecting levers must be heavy

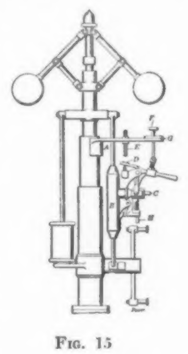


FIG. 15

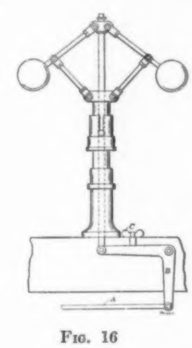


FIG. 16

enough to overbalance the center weight, flyballs, etc. With this gear the knock-off cams are utilized for safety cams, but only one set is required to both operations.

Fig. 13 represents another stop depending on an idler for its operation. As long as the belt supports this idler the engine cannot be shut down by an overload, but when the belt fails the cam *A* is reversed, and is no longer in a position to support the center weight of the governor, consequently when it falls as low as possible, the valves remain closed and the engine stops. This device acts quickly because no load is put upon the idler and all of the mechanism connected to the idler tends to carry it downward when the belt breaks.

A flyball and center weight governor attached to an ingenious device which operates the cutoff mechanism, also the stop, is shown in Fig. 14. The main parts of this device consists of two disks designated as rear and front, both of which are hung at the center. The rear disk *A* is attached directly to the governor by a vertical rod. The front disk *B* operates the two reach rods. Under normal conditions these disks move together, and transmit the motion of the governor to the cutoff mechanism.

The flyballs are shown in position for a medium load

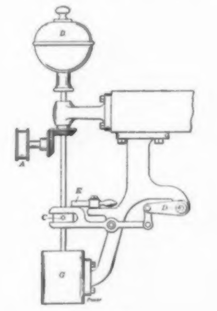


FIG. 17

on the engine. If the load is reduced the balls and center weight move upward, rotating the disks from right to left. This demonstrates that if *C* and *D* are carried to the left the cutoff is shortened, therefore if they are carried far enough the steam valves will not open. Increasing the load causes the center weight to fall, carrying *A* downward until the pawl *E* rests on the adjustable screw *F*, causing *E* to release the front disk which is quickly thrown to the left by a strong coil spring. This action rolls the cutoff cams until they prevent the steam valves from opening. But one set of cams is used to designate the point of cutoff in regular service, and to prevent the valves from opening in case of accident to the governor, without raising the center weight.

To prevent the stop motion from operating when the engine is shut down under normal conditions, a pin is inserted into both disks, thus locking them together. When the engine is started again this pin is thrown out automatically, thus making it impossible for the engineer to leave it in place, and render the stop useless.

A more complicated form of stop is shown in Fig. 15. The rod *A* corresponds to the ordinary side rod on a governor, except that its length is variable, and to shorten this length is the sole object of the device, because this section throws the ordinary reach rods to their extreme position and steam cannot be admitted to the cylinder. The enlarged part of the rod *B* is hollow and fitted with a strong spiral spring which tends to shorten the rod, but the pin *C* extends into this hollow part and prevents the operation of this spring.

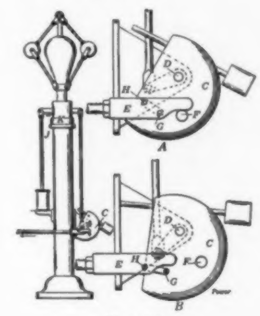


FIG. 18

Suppose that the valve gear is deranged and the engine starts to "run away." The flyballs rise, carrying the spring-supported lever *D* upward until it strikes the stationary stop *E*. As *D* is depressed by this action, *C* is withdrawn from *B*, and the inclosed spiral spring draws the reach-rod lever upward, shortening the point of cutoff to zero (without carrying the flyballs higher), and as steam cannot enter the cylinder, the engine stops.

During ordinary service the rod *F* slides freely in the plate without interfering with the action of the governor in regulating the engine speed. However, if the belt runs off, the flyballs drop to a lower plane, and the movable part of the device is lowered until *F* rests upon *G*, thus pulling *D* down as before, drawing *C* outward and allowing the concealed spring in *B* to draw the reach-rod lever up until the point of cutoff becomes shorter, and finally is reduced to zero, stopping the engine. When preparing to shut down the engine in regular service, the stop is rendered inoperative by adjusting the plug *H*, thus enabling the engineer to stop and start at pleas-

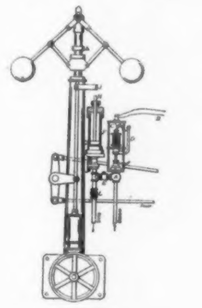


FIG. 19

ure. When the engine is started again the flyballs rise and liberate *D*, which action throws *H* back automatically into the position shown.

A very simple device for operating a stop is shown in Fig. 16. As the flyballs drop the rod *A* is carried toward the right by means of the bell-crank lever *B*, and this prevents the steam valves from opening. A slot is provided in the frame for the thumb nut *C*, allowing it to move freely vertically as long as it remains in the position shown, but if it is turned at right angles to this position it cannot pass through the slot. While turning the thumb screw prevents the device from operating in case the governor belt breaks, it is necessary to do so in order to operate the valves while starting and shutting down the engine. If the thumb nut is not set in the running position the device is no longer a safety attachment.

Fig. 17 illustrates a governor which is set low on the engine frame. The pulley *A* is driven from the crank shaft by a belt and bevel gears transmit motion to the vertical shaft, on which is mounted a pair of flyballs inclosed in an iron case *B*. If this belt breaks, the flyballs come to rest, and the vertical shaft is drawn upward, the revolving collar *C* moving with it, thus turning the side shaft *D* through part of a revolution. This action prevents the steam valves from opening.

This stop will not operate while the hand lever *E* is

in the position shown, because it prevents *C* from rising, but when given one-quarter revolution *C* is at liberty to rise. A dashpot *G* prevents *C* from rising and falling rapidly.

Another type of stop and its operating mechanism is shown in Fig. 18. Two views of the tipping device are shown at *A* and *B*; *A* shows the position taken with a light load on the engine. The half-circular plate *C* is carried by a short shaft. The reach rod *E* rests upon the pin *F* and is held there by gravity, also by action of the link. The pin *G* is set into the reach rod and *H* is a similar pin set into the plate *C*. Therefore the stress upon the rod in the direction of the arrow will hold *E* more firmly on the pin *H*.

If the governor belt breaks, *J* is lowered into the slot in the moveable collar *K*, and the action is further illustrated by *B*. The plate *C* has turned toward the left until the pin *H* is lower than pin *F*, causing the link to reverse its position, thus moving *E* toward the left twice the length of the link, which is sufficient to operate the stop.

A stop operated by electricity is shown in Fig. 19, used in connection with a Corliss governor, but it is suitable for several other types of valve gear. Steam at boiler pressure is admitted to the angle valve *A*, which is closed under normal conditions. When the crankshaft speed exceeds the limit for which this stop is set, a special governing device closes the electric circuit *B* and the armature *C* releases the lever *D*. This action allows steam to open *A*, when it passes through the check valve *E* into the vertical cylinder *F*, causing the piston *G* to rise and the rod *H* to lift *J* until the collar *K* prevents it from going higher, thus raising the flyballs to their highest position, and rolling the knock-off cams on the valve gear so far around that they prevent the steam valves from opening.

When *D* is replaced, *A* is closed, and by opening the drip *L* all pressure is released from *F*, thus allowing the piston *G* to resume the position shown, when the stop motion is ready for service. Then the throttle valve is closed, the steam valves hooked up, and the engine is ready to start.

The Exploitation and Culture of India Rubber Plants

Business Aspects of the Question

The success of India rubber culture or even of the exploitation of wild plants, is not always certain. It depends upon a great number of conditions which have not received the attention which they deserve. The problem is one of great complexity. The India rubber plant is not a single species, but there are many plants, native in various parts of the globe, from which India rubber can be obtained, and every tropical region has its special indigenous plants. Can all of these be exploited or cultivated profitably, or should one be selected for cultivation everywhere? Would it be better to abandon the collection of wild rubber and to cultivate new indigenous or foreign species? Many African colonists do not hesitate to reply that the cultivation and even the rational exploitation of the native rubber vines should be abandoned and replaced by the cultivation of the Brazilian species *Hevea* and *Manihot Glaziovii*, which they regard as superior in many respects to the African rubber tree *Funtumia elastica* (*Kickxia elastica*). In Java and British India the cultivation of the *Ficus elastica* is gradually being replaced by that of the *Hevea* which has been planted largely in the Federated Malay States and the Straits Settlements. Mons. E. de Wildeman, the curator of the botanical garden of Brussels, who discusses these questions in *La Nature*, approves the extension of the culture of the *Hevea*, but not the abandonment of the culture and exploitation of suitable indigenous plants. He supports this view, with regard to Africa, at least, by the following considerations:

Tropical Africa produces a great variety of India rubber plants, including vines which contain rubber in their stems, roots, or both; herbs which contain rubber in their roots or tubers only, and trees from which rubber can be obtained by means of incisions in the bark. In all of these three groups we find productive rubber plants which have been exploited by the natives, in some cases long before the period of European colonization. No one of these plants can be cultivated everywhere, for the different species require different conditions of life. Hence the choice of a species must be made carefully and no species foreign to the region, even if indigenous to the continent, should be planted extensively, before preliminary experiments have been made, not with a few plants, but with several hundreds, at least. The plants behave very differently according as they are cultivated singly with great care or planted closely in large numbers. The dense plantations are subject to diseases and require many precautions.

The plant, then, should be suitable to the region and consequently it is desirable to propagate the native species. In Africa, in particular, certain vines known to be extremely productive should be cultivated.

Another important question is that of labor. If the cultivation of the *Hevea* is profitable in the Malay States and Straits Settlements it might be thought that it would be equally profitable in Africa, where the climatic conditions are very similar. In Africa, however, we do not have the same class of laborers. The coolies of Java and Ceylon are unquestionably much more competent than the African negroes, with rare exceptions. The production of India rubber from the *Hevea* requires not only the comparatively simple work of cultivation, but the very delicate operation of tapping or bleeding. In Asia this operation is performed with a minute care which cannot be expected from African negroes, unskilled in work of this sort and averse to regular work of any kind. The very life of the plantations would be jeopardized by putting them in the hands of unskilled workers. Hence, until the natives have become more civilized it would be better to allow them to treat the indigenous rubber plants as they have done for many years, meanwhile establishing, in suitable places where laborers are abundant and can be watched, experimental plantations, which may have a great influence on the economical future of the region.

In the Belgian Congo extensive cultivation of the *Hevea* is being earnestly advocated, although no commercial company has yet undertaken this culture on a large scale. The sanguine expectations are based on the few successful results obtained in experimental plantations, but the economic value of the cultivation of any particular species of India rubber plant can not be definitely fixed without observations extended over from 3,000 to 5,000 trees. This does not mean that it is necessary to abandon the cultivation of the *Hevea* in Africa and every other region where it is not indigenous. Extensive cultivation should be commenced, however, with the native vines and the *Funtumia*. When favorable results have been obtained from many large plantations of *Hevea* we can judge whether it is necessary or desirable to substitute the Brazilian plant entirely for the native species. It appears probable that the native plants will maintain their superiority. Every tropical colony and, indeed, every country and every natural division of a country should remain its indigenous products.

Another important question concerns the method of extracting the latex from which India rubber is obtained. We do not yet understand the utility of the latex to the plant. Is this liquid, which contains various useful substances, a waste product of no further use to the plant? Is it a means of defense against enemies, or does it contain ingredients which again enter into the life of the plant? There is probably some truth in each of these hypotheses. At all events, the removal of the latex always causes a disturbance in the life of the plant, diminishing its vitality and power of resistance to disease. In all intensive cultivation, diseases are constantly becoming more virulent and the pathology of plants is becoming a more important science to the agriculturist.

Numerous experiments made in the Straits Settlements and the Malay States, appear to prove that the only practical method of exploiting the *Hevea* is by means of the "half herring-bone" system of incision, deepened daily or every other day. In this manner all the bark of the trunk is removed in a time which varies with the skill of the workmen. The bark is gradually renewed, but a time arrives when only a very small portion of the original bark remains. The operation is then recommenced on the new bark, which is usually four years old. The primitive bark is generally seven years old when the first incisions are made. The cultivation of the *Hevea* has not continued long enough to make it certain that this method can be pursued indefinitely without destroying the plantation. For this reason it appears more advisable to employ the rather brutal process which is still used by the natives of many tropical regions, and which consists in felling the tree at once. It is an error to suppose that this barbarous method necessarily destroys the rubber plantation or forest. If the natives are allowed to fell every rubber tree they find, the number of productive trees will certainly diminish, but if the trees to be felled are selected with care, or even if the natives are given a free hand without being urged to excessive production, the young growth will, after a certain number of years, form a productive plantation. Rubber vines also should be cut off, instead of being tapped.

The idea of extracting rubber from the bark of the *Funtumia* by a mechanical process appears to be due to Prof. Warburg of Berlin. This method has been abandoned in some districts. It has recently been taken up experimentally with excellent results in French Africa. With the *Funtumia*, then, regulated felling and mechanical extraction of the rubber from the bark appear capable of furnishing a maximum quantity of rubber and also of insuring the maintenance of the plantation by natural growth.

We know that India rubber can be obtained by mechanical processes from all three groups of African rubber plants, herbs, vines and the *Funtumia* tree, and for tropical Africa in present conditions this method appears preferable to any other.

Still another question of very great importance concerns the capital required in the cultivation and exploitation of rubber plants in the Malayan Peninsula. A hectare ($2\frac{1}{2}$ acres) planted with *Hevea* trees is worth \$4,600, even before the plants are old enough to be incised. The same land a few years ago was worth only \$100. In presence of such fluctuations of value the economic conditions of cultivation are totally changed, and another argument is advanced in favor of the exploitation of native species, which requires much smaller capital. Mons. Brenier says that this excessive increase in the price of India rubber plantations reacts in favor of the wild rubber of Brazil and Africa. It should be noted here that the Brazilian rubber-producing States are not only seeking to exploit the natural forests more rationally, but are also encouraging the formation of plantations of the *Hevea* which should succeed on its native soil better than elsewhere.

It is certain that the world has room for extensive plantations of rubber trees and that immense quantities of rubber can be produced and used to advantage; but it is equally certain that a day of overproduction will come sooner or later. If all the young plantations now in existence shall in a few years produce as abundantly as the old plantations, overproduction is inevitable and near. The constant developments in industrial chemistry will increase the employment of regenerated and inferior rubber, perhaps of substitutes for rubber, and this will naturally lower the price. The date of this overproduction does not appear so near when we note that a large proportion of the trees now planted, especially in Eastern Asia, are unproductive, owing to errors in cultivation and in selection of plants and soil. Mons. Brenier proves that the competition which is bound to come will leave in existence only those plantations which have been established in the best cultural and commercial conditions, and have received the greatest care in selection of plants, cultivation, collection and preparation of rubber, in the prevention of disease and in the maintenance of a force of competent workmen. In a word, the successful companies will be those which treat their trees most scientifically, such as the larger companies of the Malayan Peninsula, each of which maintains its private staff of chemists, botanists, mycologists, etc.

An attentive examination of the numerous problems presented by the cultivation of rubber plants only serves to show the depth of our ignorance in regard to the history, life and proper cultivation of these plants. Every country which is directly interested in the production of rubber should give serious attention to the study of local production and should establish botanical and chemical laboratories, working in harmony with the experimental plantations. Holland has long followed this excellent plan and some English colonies have also founded laboratories. Within a few years Germany has established experimental plantations and laboratories in several colonies, and schools of research and instruction, devoted especially to rubber culture, have been opened in Berlin. This example will probably be followed in England. The complex problem of the rubber industry can only be solved by constant harmonious co-operation between men of science and men of practice. The solution will not be obtained in a short time.—*La Nature.*

What Men Do with Their Dead

To many persons, death is incomprehensible. Even civilized men shudder at the sight of the dead face of a man whose mental powers have won their admiration. Death inspires still deeper awe in primitive peoples, who regard it as the work of supernatural powers, invoked by sorcery. If a beetle harms or a moth flutters about the corpse, the insect is believed to harbor the soul that has left the body. The methods of disposing of the dead are based on these beliefs. These methods will be copiously illustrated at the approaching International Hygiene Exhibition in Dresden. The following notes are quoted from *Hygieia*, the journal of the exhibition.

The dead person may be regarded as a friend or as a foe, and the treatment of the corpse varies accordingly. Almost all races, even the most primitive, render some services to the dead, if only for the sake of performing a duty and escaping post-mortem vengeance. The Tasmanians believe that the souls of the dead migrate to planets, hence they deposit corpses in hollow trees. This practice suggests the origin of the coffin. It is often considered essential for the dead man to rest in his native soil. Hence migrating tribes have carried some of the home soil with them in their wanderings, for filling graves.

These are some of the friendly offices to the dead. When the spirit of the deceased is feared as an enemy, the treatment of the body is very different. In many cases it is left lying in the house of death, which is then tightly closed and shunned with superstitious awe. The idea of separating the dead from the living is expressed still more clearly by the practice of fettering the corpse before burial. In this way the possibility of return to life is supposed to be prevented. The practice of cremation is partly based on this fear of the dead man's return. The ashes or unconsumed bones are usually inclosed in a suitable vessel. The custom of exposing the corpse to be devoured by wild beasts and birds is still practised by the Parsees. It indicates a high degree of contempt and aversion. The body is rendered quite harmless and the mental powers of the deceased are compelled to seek refuge in the sharers of the feast. The disposal of the dead serves to illustrate the general law that the apparently hygienic precautions of primitive races are founded on fear of demons and sorcerers. This is true, to some extent, of the art of medicine in general.

Shearing Sheep by Machinery

How Frenchmen Have Improved an American Invention

SOME agricultural operations which can be accomplished rapidly and perfectly by machinery are still performed almost everywhere by hand, with very primitive tools. The machines devised for such work are, in general, employed only in large establishments, as they are too costly for small farmers and are otherwise unsuited to their needs. Some machines, however, are moved from farm to farm, so that they may serve all the farmers of a district. In France, this expedient appears to have been adopted first in the case of distilling apparatus. Itinerant threshing machines and sawmills are now common.

A similar method has lately been adopted for shearing sheep, and the work which formerly occupied weeks can now be accomplished in one day by a portable apparatus. Machine tools, driven by a crank and flexible transmission, have long been employed for shearing sheep and clipping horses. This device requires two men for each animal shorn, one man turning the crank while the other applies the shears or the clipper, but it expedites the work, clipping a horse in one hour and shearing a sheep in five minutes, and it spares the animal the wounds which are frequently inflicted by hand shears. An electric motor can advantageously be substituted for the man who turns the crank.

A great advance has been made by the introduction of an explosion motor capable of operating several machines at once.. A wagon maker at Gaissy in Champagne has constructed a traveling sheep-shearing es-

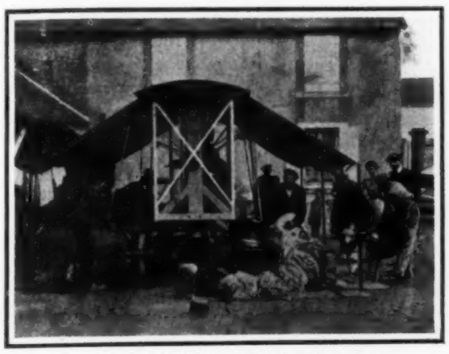


FIG. 1.—A SHEEP SHEARING CAR

tablishment equipped with 4, 6 or even 10 shearing machines, driven by a single motor. The apparatus has been employed with success on the flocks of Champagne, and it attracted much attention at a recent agricultural exhibition. It is mounted on an ordinary four-wheeled platform truck.

A small gasoline motor, of 5 horse-power, drives a horizontal shaft, to which each of the shearing machines is connected by the flexible transmission described below. The car is furnished with benches on which the sheep are placed and with a removable canvas roof.

The shearing machines are arranged in pairs, to right and left of the driving shaft, to which each machine is connected by an arm composed of three segments joined in such a manner that it can be moved freely in any direction. Two of these segments are tubular, and contain an endless cord which passes over a grooved wheel on the driving shaft, and a second grooved wheel, carried by the shearing machine. The transmission is illustrated by Fig. 2. The tubular segment *D* and *E* are suspended from one end of the solid rod *B*, which carries a counterpoise *C* at its other end. The tubes *D* and *E* are connected to the rod *B*, to each other and to the shearing machine *T* by the universal joints *F*, *G*, *H*. When the particular shearing machine shown in the illustration is not in use the weight of the counterpoise *C* causes the rod *B* to stand nearly vertical, in which position it releases the clutch which connects the grooved wheel *P* with the driving shaft and allows this wheel to stand idle, though the shaft, driven by the belt *R*, may be rotating and operating the other machines. In order to bring the machine *T* to the sheep's fleece it is necessary to pull it downward, depressing the rod *B* to a posi-

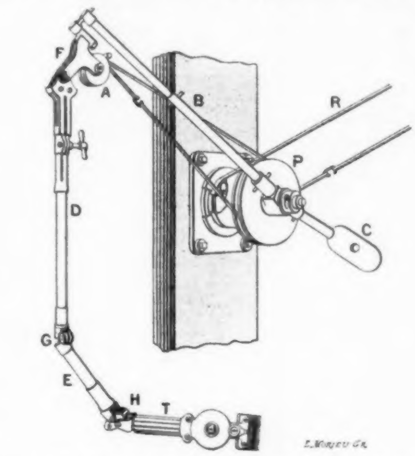


FIG. 2.—THE FLEXIBLE TRANSMISSION

tion in which it clutches the wheel *P* to the driving shaft. The endless cord passes over two guide wheels *A*, at the first joint *F*, and over two smaller guide wheels at each of the joints *G* and *H*.

The shearing machine is illustrated by Fig. 3. The two parts of the endless cord, after traversing the tubular handle of the implement, are guided by two small wheels *G*, *H*, to a large grooved wheel. A pin, placed eccentrically on the face of this wheel, engages with a fork on one end of a lever, the other end of which is attached to the toothed blade *P*. Hence the rotation of the wheel gives a reciprocating motion to the toothed blade, which slides over a fixed comb, as in an ordinary clipper.

The shearing car shown in Fig. 1 carries six shearing machines and a set of machine tools for sharpening blades and other purposes. As each machine can shear a sheep in 5 minutes, 720 sheep can be sheared in a day of 10 hours.—*La Nature*.

The Interior of the Earth

THE interior of the earth is scarcely more accessible than the stars to direct experimentation, and is less known through valid indirect evidence. Some information is given by earthquake shocks which, though local in origin, shake the whole earth. By collating the records of seismographs in various places it has been learned that the velocity of the earthquake wave is 3 or 4 miles per second in the upper strata of the earth and more than 10 miles per second in the central nucleus. The earth, as a whole, may be compared to a great spherical bell which when struck makes only two or three complete vibrations per hour. As the note emitted by a piano string depends on its length, thickness and tension, so the "note" of the earth-bell and the velocities of waves in its different parts give some indication of the state of the concentric strata of which the earth is composed.

The information thus obtained is very incomplete, and scientists have endeavored to fill its voids by means of various plausible hypotheses. A review of our present knowledge of the earth, recently presented to a French scientific society, contains two remarks of especial interest, concerning the variations of gravity and pressure in the earth's interior.

If a shaft were sunk vertically to the center of the earth and an object, suspended from a spring balance, were lowered down the shaft, the weight of the object, as indicated by the dial of the balance, would at first increase, as the descending object approached the deeper and denser strata. After passing a certain depth, however, the weight would begin to diminish, and it would continue to diminish to the center of the earth, where its value would be zero, because the object would there be equally attracted in every direction.

The pressure increases enormously with increasing depth below the earth's surface. It must be about 200,000 atmospheres at a depth of 400 miles (1/10 the earth's radius), 4,000,000 atmospheres at 2,000 miles (half the radius), and more than 100,000,000 atmospheres at the center. At such pressures the materials of the earth, though heated above their melting points, are probably quasi-solid and as rigid as glass or steel. Hence the velocity of propagation of vibrations must exceed the velocity of sound in ordinary solids, such as cast iron, in which it is 20,000 feet per second.

Directed Wireless Telegraphy

THE Bellini-Tori system of directed wireless telegraphy is now in practical use on land and sea, according to a letter addressed to *La Nature* by the inventors, and has

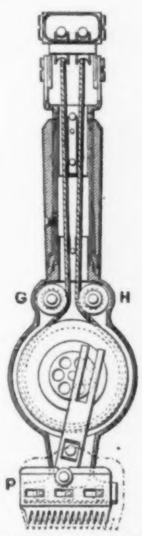


FIG. 3.—THE SHEARING MACHINE

given entire satisfaction. At Boulogne, France, the system has been in continuous operation since January, 1910. It works perfectly and has rendered great service to navigation. The station uses a wave length of 300 meters (984 feet) and a range of 300 kilometers (186 miles). On shipboard a special application of the system is made, so that the position of the vessel can be determined in foggy weather by means of the coast wireless stations. The position is thus found as accurately as it can be determined by the ordinary usual methods in clear weather.

TABLE OF CONTENTS

INDEX OF INVENTIONS

For which Letters Patent of the United States were Issued for the Week Ending March 7, 1911,

AND EACH BEARING THAT DATE

[See note at end of list about copies of these patents.]

A printed copy of the specification and drawing of any patent in the foregoing list, or any patent in print issued since October 4th, 1859, will be furnished from this office for 10 cents, provided the name and number of the patent desired and the date be given. Address Munn & Co., Inc., 361 Broadway, New York.

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